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THE CLASSIFICATION OF THE WAVERLY SERIES OF CENTRAL OHIO[1]

INTRODUCTION

PERHAPS it may seem strange that a consideration of the classification of the Waverly series[2] is proposed after the thorough investigations of the Ohio Geological Survey directed by Doctors Newberry and Orton. Their investigations gave the world the main facts concerning the economic and general geology of the state and the names of Newberry and Orton will be associated for all time with the geology of Ohio as those of Mather, Emmons, Vanuxem, and Hall are with that of New York, and Henry D. Rogers and Lesley with that of Pennsylvania. It is true of geology, however, as of other sciences that the scope is constantly widening so that a restatement of facts or, perhaps, another investigation of the whole subject, aided by later discoveries, may be required. At present this is especially true with reference to the stratigraphical geology of America. During the lifetime of Dr. Newberry the nomenclature of

[1] Published by permission of Professor Edward Orton, Jr., state geologist of Ohio. Presented to the tenth meeting of the Ohio State Academy of Science, Columbus, December 27, 1900.

[2] Series is used in the sense proposed by the International Congress of Geologists. See Work Inter. Cong. Geologists, 1886, p. 50; GILBERT, in Proc. A. A. A. S., Vol. XXXVI, 1888, p. 186; and Congrès Géologique International (8e Session), Procès-verbaux des Séances, 1901, p. 34.

geological formations was not closely scrutinized and there were very few clearly defined rules governing the naming of the various geological divisions. In general, the names referred to some locality in which the rocks were more or less favorably exposed. But this was not always the case, for not infrequently mineralogical or paleontological terms were used for the names of the divisions. Much the same system prevailed during the period of the more active investigations of Dr. Orton and it is only during the last few years that the movement has arisen to place the nomenclature of stratigraphical geology on a basis similar to that of the biological sciences. Two of the most potent influences in this movement are the International Congress of Geologists and the United States Geological Survey. The most important principles of nomenclature governing the United States Survey are: first, a formation is a lithological unit representing the physical conditions of deposition, and should be called by the same name so far as it can be traced and identified by means of its lithologic characters aided by its stratigraphic associations and its contained fossils. The formation shall receive a distinctive designation, the preferred form being binomial of which the first member is geographic and the other lithologic. When the formation, however, consists of beds differing in lithologic character, so that no single lithologic term is applicable, the word "formation" shall be substituted for the lithologic term. The second principle is the rule of priority.[1] These two principles of nomenclature have been very imperfectly observed in most of our stratigraphical geology and as recently as December 1899, Dr. J. M. Clarke, state paleontologist of New York, and Mr. Charles Schuchert published a revised classification of the formations of New York in which a number of time-honored names were replaced by new terms.[2]

REVIEW OF FORMER CLASSIFICATIONS

In 1838 Professor C. Briggs, Jr., the fourth assistant geologist of the first geological survey of Ohio, proposed the name

[1] Tenth Ann. Rept. U. S. Geol. Surv., 1890, pp. 64, 65.

[2] Science, N. S., Vol. X, 1899, pp. 874–878.

"Waverly sandstone series" for the rocks occurring between the "argillaceous slaty rock, or shale stratum," now known as the Ohio shale, and the "conglomerate" which lies at the base of the Coal-measures. Waverly is the name of the capital of Pike county in southern Ohio and Professor Briggs stated that "As some of the most beautiful stones that have been obtained were quarried at Waverly, we may, for the present, denominate these rocks the Waverly sandstone series."[1]

In the following report, for some reason, Professor Briggs used the term "fine-grained sandstone" in place of the Waverly in his descriptions of the geology of Hocking, Athens, and Crawford counties.[2]

In the first report of the Newberry survey, Dr. Newberry and Professor Andrews revived the name, "Waverly sandstone."[3] Professor Andrews stated that it consisted of "A group of sandstones and shales, measuring on the Ohio River 640 feet in thickness (from the black slate to the base of the sub-Carboniferous limestone in the Kentucky hills), [which] rests conformably upon the black slate."[4] He further described a stratum of bituminous black shale 16 feet in thickness, 137 feet above the base of the group to which he gave the name "Waverly black slate."[5] It was also stated that between the Coal-measures and Waverly in Hocking county was "a group of comparatively fine-grained, buff-colored sandstone," 133½ feet in thickness which was named the Logan sandstone."[6] Below the Logan sandstone was given 85 feet of rocks which were stated to be composed of fine-grained sandstones alternating with conglomerates and this

[1] First Ann. Rept. Geol. Surv. Ohio, p. 80.

[2] Second Ann. Rept. Geol. Surv. Ohio, 1839, pp. 122, 130. See also his section of the strata of Ohio, facing p. 109. The same term was used by Mr. Foster, another assistant; see pp. 76 and 103, and, facing p. 73, his "Geological section along the National road from the Scioto River to the eastern line of Muskingum county."

[3] Geol. Surv. Surv. Ohio, Pt. I, Rept. Progress in 1869, 1870, p. 21; Pt. II, p. 65.

[4] *Ibid.*, Pt. II, p. 65. [5] *Ibid.*, p. 66.

[6] *Ibid.*, p. 76. The "section on Hocking River" on the "map showing the Lower Coal Measures" at the close of this report gave the thickness of the Logan sandstone group as 144 feet.

division in some parts of the report is called the "Waverly conglomerate."[1] Professor Andrews identified these two divisions in the Licking Valley and stated that "at Black Hand, near the east line of Licking county, the conglomerate is probably fifty or sixty feet thick, and over it lies, as we follow the dip to the southeast toward Zanesville, the Logan sandstone group. The Logan sandstone, with its characteristic fossils, is found to extend to a point between Pleasant Valley and Dillon's Falls, on the Baltimore and Ohio Railroad."[2]

Dr. Newberry stated that the Waverly group, as it was then called, "In the northern part of the state . . . . is much less homogeneous [than in the southern part], and is composed of the following elements:

	Feet
Cuyahoga shale (dove-colored shale and fine blue sandstone)	150
Berea grit (drab sandstone)	50
Bedford shale (red and blue clay shale)	60
Cleveland shale (black bituminous shale)[3]	20–60."

This classification was repeated by Dr. Newberry in 1873 in his report on the geology of Cuyahoga county, with a revision of the thickness of the several divisions, as follows:

		Feet
Waverly group	Cuyahoga shale	150–200
	Berea grit	60
	Bedford shale	75
	Cleveland shale[4]	21–60

At a later date the Cleveland black shale was referred by Dr. Orton and some other geologists to the Devonian system. The same classification for the Waverly was given by Dr. Newberry in 1874 under his description of the Carboniferous system.[5] In this volume Professor N. H. Winchell reported numerous outcrops of the Berea grit succeeded by the Cuyahoga shales and

[1] See p. 135 and explanation of the "section on Hocking River" on the "map showing the Lower Coal Measures."

[2] *Ibid.*, p. 79. Also see *ibid.*, Rept. Progress in 1870 [1871], p. 59.

[3] *Ibid.*, Pt. I, Rept. Progress in 1869, p. 21.

[4] Rept. Geol. Surv. Ohio, Vol. I, Pt. I, p. 184.

[5] *Ibid.*, Vol. II, Pt. I, p. 87.

sandstones in northern central Ohio in Crawford, Morrow, and Delaware counties.[1] This identification of Professor Winchell's is important because it carried correctly, for the first time, the Berea grit with the overlying Cuyahoga shale from northern Ohio to the central part of the state. Dr. Orton published the descriptions of the geology of Pike and Ross counties in this volume, and gave the following subdivisions of the Waverly series:

At the base are from 80 to 100 feet of the *Waverly shales*,[2] a name apparently proposed by him. This was followed by what he termed the *Waverly Quarry System*, with a thickness of 32½ feet, one mile south of Jasper.[3] Immediately above the sandstone is a black shale, from 16 to 27 feet in thickness, which, Dr. Orton stated, had been "designated by the chief geologist the '*Cleveland shale*' and by Professor Andrews the '*Waverly black slate;*'"[4] while the remaining part of the series, including everything "above the Waverly black slate and below the Carboniferous series" was denominated the Upper Waverly, composed of shales and sandstones with a maximum thickness not exceeding 425 feet.[5]

Meek in 1875, in giving the horizon of *Discina* (*Orbiculoidea*) *Newberryi* Hall, stated that certain specimens came "from the Berea shale, a member of the Waverly group of the Lower Carboniferous,"[6] which is, apparently, the first usage of the name in a stratigraphical sense, although it does not clearly appear that Meek intended to separate the shale from the subjacent Berea grit.

In 1878 Dr. Orton's "Report on the geology of Franklin county" was published, and in it occurs a description of the Waverly group as far as represented in the county. The Huron shale, the youngest formation of the Devonian system, was described as closing with "a red or chocolate-colored band, from

[1] *Ibid.*, pp. 240, 259, and 280.

[2] *Ibid.*, p. 619. [3] *Ibid.*, p. 621. [4] *Ibid.*, p. 624. [5] *Ibid.*, p. 649.

[6] Rept. Geol. Surv. Ohio, Vol. II, Pt. II, Palæontology, p. 278. See also statements in explanation of Plate XIV.

15 to 20 feet in thickness." Outcrops of these red shales were mentioned as occurring at "Taylor's Station, in Jefferson township, and at several points in Mifflin township, on the eastern bank of Big Walnut Creek. One exposure in particular may be named, which is very conspicuous, viz., the one seen in the slate cliff, opposite Central College."[1]

Dr. Orton's correlation of the divisions of the Waverly was as follows:

		Feet
Waverly group of the sub-Carboniferous period	Cleveland shale - - -	15
	Waverly quarry system -	60
	Waverly shales[2] - - -	10–20

In the report above mentioned Dr. Orton said "the Cleveland shale of Dr. Newberry, the Waverly black shale of Professor Andrews . . . . is known at but a single locality in the county, viz., at Ealy's Mills, in Jefferson township, on the banks of Rocky Fork. From 10 to 15 feet of this formation are here shown within the compass of an acre."[3] Dr. Orton further stated that Professor Winchell was in error in correlating the sandstone at Sunbury, Delaware county, with the Berea grit, his statement being as follows: "The Sunbury stone is erroneously referred in Vol. I [Vol. II] to a higher division of the Waverly, viz., the Berea grit, but it certainly belongs to the lowest of the sandstone courses of this formation."[4] The same volume contains the "Report on the Geology of Licking County," by M. C. Read, who described therein the upper Waverly of that county. The oldest division noted by Read was the *Waverly conglomerate*, which was said to be "conspicuously exposed along the south bank of the Licking in Madison and Hanover townships, presenting abrupt, precipitous bluffs 20 to 40 feet high."[5] The conglomerate was succeeded by the "olive shales," which were said to occupy "an interval of 150 to 190 feet below the Carboniferous conglomerate,"[6] and were described as composed mainly of shales, but with some "strata of massive sandstone."

[1] Rept. Geol. Surv. Ohio, Vol. III, Pt. I, p. 638.
[2] *Ibid.*, p. 639.
[3] *Ibid.*, p. 642.
[4] *Ibid.*, p. 642.
[5] *Ibid.*, p. 360.
[6] *Ibid.*, p. 359.

In July 1878 Professor L. E. Hicks, of Denison University, announced "the discovery [of] an unmistakable outcrop of Cleveland shale [which] exists two miles east of Sunbury in Delaware county, southern [central] Ohio, on the land of Horace Whitney. It lies *above* the calcareous sandrock of the Sunbury quarries, which Professor N. H. Winchell, a special assistant of the Ohio geological survey, identified as *Berea grit*. My discovery *demonstrates* the incorrectness of that identification, and raises a strong presumption, amounting almost to a certainty, that he was equally wrong in respect to his Berea grit in Morrow and Crawford counties."[1] Professor Hicks made no reference to the classification of the Waverly and identification of the Cleveland shale in Franklin county by Dr. Orton, and on the other hand Dr. Orton did not mention Professor Hicks' papers in any of his publications so I am unable to state which article has priority. The September number of the same periodical contained a classification of the Waverly group in central Ohio by Professor Hicks, which was stated to include the rocks lying between the Huron shales and the base of the Coal-measures. The classification is as follows:

	Feet thick
5. Licking shales	100–150
4. Black Hand conglomerate and Granville beds	85–90
3. Raccoon shales	300
2. Sunbury black slate	10–15
1. Sunbury calciferous sandrock[2]	90–100

The following year Dr. Orton published a "Note on the Lower Waverly Strata of Ohio" in which for the first time the Waverly black shale of southern Ohio was correctly correlated with the black shale directly above the Berea grit in northern Ohio for which the name Berea shale was proposed. This furnished the key for the correct correlation, between northern and southern Ohio, of the lower formations of the Waverly series, which was summarized in the following table:

[1] Am. Jour. Sci., and Arts, 3d ser., Vol. XVI, p. 71.

[2] *Ibid.*, p. 216.

Northern Ohio	Southern Ohio
Cuyahoga shale - - 150–250 ft. Upper beds fossiliferous	Shale and sandstone - 300–400 ft. Upper beds fossiliferous
(Berea shale) - - - 10 ft. Included by Newberry with Cuyahoga	Waverly black shale - - 15 ft.
Berea grit - - - - 60 ft.	Waverly quarries and overlying blue shale - - - - 60 ft.
Bedford shale - - - 75 ft.	Waverly shale - - - 90 ft.
Cleveland shale	Great black shale [1]

In 1888 Dr. Orton published a general classification of the Waverly group which he considered as composed of the Bedford shale, the Berea grit, the Berea shale, the Cuyahoga shale, and the Logan group. The Cuyahoga shale, however, was restricted to the shales and fine-grained sandstones between the Berea shale and the base of the conglomerate and sandstone forming the upper part of the Waverly. This upper division was called the Logan group which was said to consist of the Waverly conglomerate and Logan sandstone of Andrews as found in Hocking, Fairfield, and Licking counties. To the north the olive shales of Read in Knox and Richland counties were correlated with the Logan sandstone.[2] The same classification was republished by Dr. Orton in his last report for the Ohio survey.[3]

In 1888 Professor C. L. Herrick, who had studied the paleontology and stratigraphy of the Waverly series of central Ohio more thoroughly than any of the former observers, published his conclusions. Professor Herrick had also studied the Waverly of northern and southern Ohio and rocks of similar age in Pennsylvania and western New York, so that his classification was not intended to be confined to the rocks of central

[1] *Ibid.*, Vol. XVIII, p. 139.

[2] Rept. Geol. Surv., Ohio, Vol. VI, pp. 33–42.

[3] *Ibid.*, Vol. VII, 1893 [1895], pp. 26–35.

Ohio. The upper part of the series he correlated with the formations of the Mississippi valley and two quite persistent conglomerate horizons were named Conglomerate I and II.[1]

The classification is as follows:

Cuyahoga or Waverly series
- Logan — Keokuk, 100–150 ft. / Burlington
- (Conglomerate II)
- Kinderhook, 50–60 ft.
- (Conglomerate I)

Berea or Transition series (Western equivalent of Upper Chemung)
- Waverly shale, 40 ft.
- Berea shale, 200–400 ft.
- Berea grit, 50–60 ft.
- Bedford shale, 50 ft.
- Cleveland shale (local), 50 ft.

Erie shale,
Eastern or typical Chemung (lower part), 100 ft.[2]

In the above classification the Berea shale included Dr. Orton's Berea shale and all of his overlying Cuyahoga shale except its fossiliferous upper 40 feet which, extending to the base of Conglomerate I, was called the Waverly shale.

In 1889 Dr. Newberry stated that the Waverly group "where best seen, as in northeastern Ohio, ... is about 500 feet thick, and fills the interval between the Erie shale (Chemung) below and the Carboniferous conglomerate above."[3] The following classification of the Waverly group was given:

	Average thickness feet
1. Cuyahoga shale	230
2. Berea shale	20
3. Berea grit	60
4. Bedford shale	75
5. Cleveland shale[4]	50

[1] Bull. Sci. Lab., Denison University, April 1888, Vol. III, p. 24; see also section on p. 26.

[2] *Ibid.*, December 1888, Vol. IV, pp. 105, 106. The zones of these formations with their characteristic fossils and thickness are given in detail on pp. 99–101.

[3] Mon. U. S. Geol. Surv., Vol. XVI. The Paleozoic Fishes of North America, p. 120.

[4] Loc. cit.

It will be noticed that Dr. Newberry accepted the separation of the Berea shale from the Cauyhoga shale; but did not accept the reference of the Cleveland shale to the Ohio shale. This point he discussed quite fully and stated that the union of the Cleveland, Erie, and Huron shales to form the Ohio shale seemed unwarranted.[1] Dr. Newberry referred to Professor Hicks announcement of the discovery of the Cleveland shale in Delaware county, saying in conclusion: "I think he has found there the Berea shale, which lies immediately above the Berea grit."[2]

In 1891 Professor Herrick reviewed the general stratigraphy of the Waverly series, commencing with the Bedford shale. The lower boundary of the Waverly, however, he thought "must be found in the Berea grit, which . . . . is a sharply limited and easily recognizable horizon throughout Ohio."[3] The Berea grit came next, followed by the Berea shale, which, he states, is a term "conveniently applied to the thin band of bituminous shale above the grit, and perhaps should not be extended (as the writer has done in a previous paper) to the gray and blue shales above."[4] For the overlying rocks he used the name Cuyahoga shale in the sense in which it was used by Dr. Orton, except that the upper 40 feet, as in the previous paper, was called the Waverly shale. This division was stated to be stratigraphically continuous with the Cuyahoga shale which it also resembled lithologically, but paleontologically it more closely resembled the succeeding division or Kinderhook. The last division was called the Burlington and Keokuk.

REVISED CLASSIFICATION

This concludes the review of all the important papers published concerning the classification of the Waverly series of central Ohio. As a result of this study followed by an examination of the formations in the field, the writer proposes the following classification for the Waverly series of central Ohio.

[1] *Ibid.*, p. 128.
[2] *Ibid.*, p. 129.
[3] Bull. Geol. Soc. Amer., Vol. II, p. 35.
[4] *Ibid.*, p. 35.

No attempt is made, however, to correlate the formations with those of the sub-Carboniferous of other states:

	Feet
6. Logan formation (Andrews)	115
5. Black Hand formation (Hicks)	40–(120?)
4. Cuyahoga formation (Newberry)	275–300
3. Sunbury shale (Hicks)	10–15
2. Berea grit (Newberry)	40
1. Bedford shale (Newberry)	85+

Bedford shale was named by Newberry in 1870[1] from the outcrops at Bedford, southeast of Cleveland, at which place, he later states, the best exposure occurs.[2] The term "Bedford rock" appears in Richard Owen's description of the geology of Lawrence county, Indiana, published in 1862;[3] but it was not used as the name of a geological division. This interpretation is apparently confirmed in the subsection of the report devoted to the general description of the sub-Carboniferous limestone where the term "Middle or Lawrence—Crawford sub-Carboniferous limestone"[4] is proposed, a name evidently employed to denote a geological division. Mr. E. R. Cumings, of Indiana University, informs me that the Bedford oölitic limestone belongs in this division.[5] Writers since Owen have used the terms "Bedford stone," "Bedford oölitic stone," and other names for the rock, which was finally excellently described in 1896 by Hopkins and Siebenthal under the formation name of the "Bedford oölitic limestone."[6] It is the opinion of the writer, however, that the term "Bedford shale" used by Dr. Newberry as the name of a formation in 1870 is the one that should stand and the Indiana formation name of Bedford oölitic limestone should be dropped. Since the above was written Mr. E. R. Cumings has proposed the name, Salem limestone, for the Bedford oölitic limestone of Indiana.[7]

[1] Geol. Surv. Ohio, Pt. I, 1870, p. 21.

[2] Rept. Geol. Surv. Ohio, Vol. I, Pt. I, 1873, p. 189.

[3] Rept. Geological Reconnoissance of Indiana during 1859 and 1860, p. 137.

[4] *Ibid.*, p. 125. [5] Letter, January 13, 1901.

[6] Twenty-first Ann. Rept. Ind., Dept. Geol. and Nat. Resources, pp. 291, 298.

[7] Am. Geol., Vol. XXVII, March 1901, p. 147.

This formation succeeds the Ohio shale, and as the Cleveland and Erie shales are supposed not to extend to central Ohio it probably rests on the Huron shale in Franklin county. The lower part of the formation in this county is well shown on the eastern bank of Big Walnut Creek east of Central College where the following section occurs:

		Thickness feet	Total thickness feet
No. 7.	Till and soil	5	87½
6.	Fine green argillaceous shale. *Bedford shale*	7	82½
5.	Mixed chocolate and greenish shale, mostly olive color	7⅓	75½
4.	Chocolate shale composed of fine clay	21⅔	68
3.	Fine green to olive argillaceous shales. Near base blocky shales containing fossils. *Base of Bedford*	17⅓	46⅓
2.	Fine black shales containing small concretions. *Huron shale*	24½	29
1.	Covered to level of Big Walnut Creek	4½	4½

The greater part of the formation is shown on Rocky Fork, commencing about one and a half miles east of Gahanna and continuing up the creek for a mile. About one fourth mile up the creek from the ford on the north and south road is an outcrop, on the southern bank, of three feet of black shale which is nearly at the top of the Huron shale. A short distance farther up the creek is a higher bank which gives the following section:

		Thickness feet	Total thickness feet
No. 3.	Till	6½	28¾
2.	Fine chocolate shales of the Bedford	7	22⅓
1.	*Bedford shales.* The upper part is somewhat sandy but the grains are very fine, and the lower part is composed of greenish to bluish argillaceous shale. Creek level	15⅓	15⅓

At the second bluff to the west of the private bridge is the following section:

		Thickness feet	Total thickness feet
No. 2.	Till	7⅔	36
1.	Chocolate argillaceous shale which weathers to a red clay. *Bedford shale.* Creek level	28⅓	28⅓

To the east of the bridge the base of the till is much lower than on the western side and there is a marked line of unconformity between the till and Bedford shale. Two hundred and twenty-five feet east of the above section is the following, which shows an irregular surface on which the till was deposited:

	Thickness feet	Total thickness feet
No. 2. Till with beds of sand - - - - - -	49⅓	54
1. Bedford chocolate shale. Creek level - -	4⅔	4⅔

The covered interval between this bank and the next one is extensive enough to hide the top of the chocolate shale and the bluff is composed of grayish shales of the upper Bedford capped by the Berea sandstone. The following section is shown on the western bank of the creek below a tree:

	Thickness feet	Total thickness feet
No. 4. Till - - - - - - - - - -	5	56½
3. Grayish sandstone layers about one foot thick. *Berea sandstone* - - - - - - -	14	51½
2. Sandy, fine-grained shales with argillaceous ones above and below - - - - - -	9¾	37½
1. At the top a sandy concretionary layer 2 ± feet thick. Shales mostly grayish and argillaceous. In the lower part are spots of reddish-gray shale somewhat similar to the mottled shale No. 5 east of Central College. Level of creek	27¾	27¾

The Bedford shale includes the red band from 15 to 20 feet in thickness, which Dr. Orton, in his report on Franklin county, considered the upper part of the Huron shale;[1] the gray shale between the red and black Huron shales which was not mentioned in the county report; and the Waverly shales.[2]

2. *Berea grit* was named by Dr. Newberry in 1870, from the large quarries at Berea, southwest of Cleveland.[3] It is well shown on Rocky Fork, to the north of the outcrops of the Bedford shale and on the banks of Big Walnut Creek about one mile northeast of Sunbury, Delaware county. There are beautiful examples of ripple marks in the sandstone at both of these localities. On the eastern bank of Rocky Fork is an exposure of 31½

[1] *Ibid.*, Vol. III, Pt. I, p. 638. [2] *Ibid.*, p. 639. [3] Geol Surv. Ohio, Pt. I, p. 21.

feet of gray, thin bedded Berea sandstone, some of the layers a foot or more in thickness, with some partings of clay shale below which are 8 feet of bluish Bedford shales partly argillaceous and partly arenaceous, while in the upper part are thin layers of sandstone. The thickness of the Berea sandstone on this creek is about 40 feet and in the upper part at the highway is a small quarry. On the western bank of the Big Walnut between the railroad and highway bridges, one mile northeast of Sunbury, there is from 26 to 30 feet of it shown in the vertical cliff. This formation is called the "Waverly quarry system" in the report on Franklin county,[1] and the "Sunbury Calciferous sandrock" by Professor Hicks.[2]

3. *Sunbury shale* was named by Professor Hicks in 1878, from outcrops on Rattlesnake Creek on the present farm of Amos Whitney, about two miles east of Sunbury. North of the Whitney house there is an outcrop of 3½ feet of this black shale on the northern bank of the creek, and it may be seen at irregular intervals for some distance down the stream. A single specimen of a *Lingula* was the only fossil found, but the lower part of the shale is concealed and the top of the Berea grit crosses the creek a little below the house of Mr. W. P. Swallow. There is a much better exposure on Rocky Fork, in Franklin county, where the contact of the shale and Berea is shown just above the highway bridge on the David Meyers farm. The lower 2 feet of the very fossiliferous shale is exposed, containing abundant specimens of *Lingula melie* Hall, and *Orbiculoidea Newberryi* Hall, together with fragments of fish bones and teeth. Farther up the creek 8 + feet of the shale is shown on the western bank resting on the Berea grit.

This shale was first inappropriately named the "Waverly black slate" by Andrews in 1870[3] because the term Waverly had already been used for the larger division which includes this shale. Geological nomenclature is being revised for the purpose of eliminating and preventing the duplication of geographic

[1] *Ibid.*, Vol. III, p. 639. [2] Am. Jour. Sci., 3d ser., Vol. XVI, p. 216.

[3] Geol. Surv. Ohio, Pt. II, 1870, p. 66.

names of stratigraphic divisions of the same or different rank. The name Berea shale, proposed by Dr. Orton in 1879,[1] is excluded, first, by the law of priority, since Sunbury shale was published and defined by Professor Hicks the preceding year, and second, because Berea had been used in 1870 by Dr. Newberry for the name of a formation. The division termed the Cleveland shales in the report on Franklin county is the Sunbury shale.[2]

4. *Cuyahoga formation* (shale) was the name given by Dr. Newberry in 1870[3] to "the uppermost member of the Waverly group" and was described as crossing Cuyahoga county and forming the banks of the Cuyahoga River to the Cuyahoga Falls.[4] Originally the Sunbury shale constituted the lower part of this formation, and in 1888 Dr. Orton separated the coarser deposits of conglomerate and sandstone in the upper part of the Waverly, as found in central and southern Ohio, from this formation, under the name of the Logan group,[5] and said this "upper member of the series [Waverly] is wanting in the Cuyahoga Valley, or is at least very inadequately represented there."[6]

Professor Herrick in 1891 from paleontological and stratigraphical evidence showed that this upper part of the Waverly is wanting in northern Ohio, and said: "We can positively assert that the Cuyahoga shale as represented in the northern tier of counties is identical with that part of the Waverly lying below Conglomerate I . . . . of central Ohio. The fossiliferous horizons of Granville, Newark, Rushville, and Winchell's Division 4, on the Ohio River, are all above the top of the Cuyahoga."[7]

Finally, Professor Herrick stated in 1893 that in the "northern localities the calcareous, concretionary layer, which has yielded so abundant a fauna in central Ohio, was discovered at

[1] Am. Jour. Sci., 3d ser., Vol. XVIII, p. 138.

[2] Loc. cit., pp. 639, 642.

[3] Geol. Surv. Ohio, Pt. I, p. 21.

[4] Rept. Geol. Surv. Ohio, Vol. I, Pt. I, p. 185.

[5] *Ibid.*, pp. 37, 39.

[6] *Ibid.*, p. 39.

[7] Bull. Geol. Soc. America, Vol. II, p. 37. See also the section of Cuyahoga Valley and Bedford, on p. 40, where it is stated that "This entire series [upper part of the Waverly] is absent in the northern tier of counties to the base of Conglomerate I."

a distance of 40 feet beneath the Coal Measure conglomerate and most of the characteristic species re-collected. This served to settle the question conclusively except for the few feet above this horizon."[1]

The present writer considers the Cuyahoga shales of central Ohio as composed of the shales and sandstones occurring between the top of the black Sunbury shale and the base of the coarse deposit called by Professor Herrick Conglomerate I. In this formation, therefore, is included the 40 feet of fossiliferous shales immediately underlying Conglomerate I of Professor Herrick which he called the Waverly shale.[2] Should a separation of this shale from the Cuyahoga prove necessary it would require a different name, because Waverly had already been used—first, as the name of a series; second as the name of the conglomerate in central and southern Ohio; third, as the name of the black shale in southern Ohio; fourth, as the name of the sandstone in the vicinity of Waverly; and fifth, the identical term Waverly shale by Dr. Orton for the lowest division of the series in southern Ohio.[3]

This formation was called the Raccoon shales by Professor Hicks, who said: "It appears in force all along Raccoon Creek and its tributaries, and extends westward into Franklin and Delaware counties."[4] Its thickness was estimated by Professor Hicks as 300 feet, while Professor Herrick stated that "the Cuyahoga proper is never more than 200 feet thick."[5]

In central Ohio the Cuyahoga formation is composed largely of bluish to grayish shales and buff sandstones which are fairly well exposed on Moot's Run and other streams in the western and central parts of Licking county.

[1] Rept. Geol. Surv. Ohio, Vol. VII, 1893, pp. 502, 503.

[2] Bull. Denison Univ., Vol. IV, 1888, p. 107.

[3] Rept. Geol. Surv., Ohio, Vol. II, Pt. I, 1874, pp. 619, 648; and Figs. 1 and 2 of the report on Pike county.

[4] Am. Jour. Sci., 3d ser., Vol. XVI, 1878, p. 219.

[5] Bull. Geol. Soc. Amer., Vol. II, 1891, p. 38.

5. *Black Hand formation* (conglomerate) is the name given by Professor Hicks in 1878 to the deposits of coarse sandstone and conglomerate exposed at Black Hand in the gorge of the Licking River and about Hanover.[1] Both of these localities are in Hanover township, in the eastern part of Licking county. We find, as in the case of most conglomerates, that when this formation is followed for some distance there are quite decided differences in the lithologic character of the rocks. In the vicinity of Newark and Granville they are mainly sandstones, with some layers of shales and two comparatively thin strata of conglomerates. Professor Hicks states that these beds are well exposed at Granville and are only a local modification of the Black Hand conglomerate, and for convenience he designated them "the Granville beds."[2] Professor Andrews in 1870 called this division the Waverly conglomerate;[3] but this name was preoccupied, because Waverly had already been used for the name of the series. He correlated the conglomerate at Black Hand with that of the Waverly and gave its thickness at that locality as probably 50 or 60 feet.[4]

At Havens' quarries, on the farm of Mr. G. W. Havens, one and one half miles southeast of the central part of Newark, is a good exposure of the sandstone phase of this formation. The section begins in the conglomerate stratum on the bank of Quarry Creek below the quarries, where an excavation has been made in prospecting for gold, and continues to the top of the bank above the quarry on the eastern side of the run. The quarry on the western side of the creek is shown in Fig. 1, the lower part of which is in the Black Hand and the upper the Logan formation.

[1] Amer. Jour. Sci., 3d ser., Vol. XVI, pp. 216, 217.

[2] *Ibid.*, p. 218.

[3] Geol. Surv. Ohio, Pt. II, p. 135, and on the explanation of the "Section on Hocking River" of the "Map showing the Lower Coal Measures."

[4] *Ibid.*, p. 79.

FIG. 1.—Havens quarry on the western bank of the stream. The lower part shows the massive sandstone of the Black Hand formation, the top of which is Herrick's Conglomerate II, indicated by the two upper students. Succeeding Conglomerate II the lower part of the Logan formation is shown.

SECTION AT HAVENS' QUARRY

	Thickness feet	Total thickness feet
No. 9. Till and soil	2	75
8. Alternating shales and sandstone	14½	73
7. Massive buff sandstone splitting into many layers	16	58½
6. Bluish argillaceous shales	4½	42½
5. Conglomerate stratum No. II of Herrick; average thickness 11 inches	1	38
4. Bluish fossiliferous shales containing numerous specimens of *Spirophyton* and other fossils; was called the "Allorisma layer" by Herrick	6½	37
3. Grit containing a few fossils	½	30½
2. Light gray to buff fine-grained sandstone, which is called freestone and quarried. This forms a massive zone which splits into several layers. The upper 8 feet of this zone is shown in this quarry, and, at the base in the gold-mine opening, nearly 3 feet of drab argillaceous shale, below which is 3¼ feet of coarse-grained buff sandstone. In the Havens quarry, on the western side of the creek, nearly 20 feet of this sandstone is shown, and in the Vogelmeier quarry, one and one half miles south of Newark, 27 feet of sandstone, separated by a 5-inch bluish shaly layer 9 feet below the top. In certain layers of this sandstone fossils are common, especially *Syringothyris cuspidatus* (Martin).		
1. Conglomerate stratum, 3 feet thick. Sandstone parting, 7 inches. Massive conglomerate with quite large pebbles, which are coarser than in the upper layer. Level of creek (Conglomerate No. I of Herrick)	5	5

From the freestone No. II of the above section the following species were collected:

1. *Syringothyris cuspidatus* (Martin) (c).
2. *Spirifer Winchelli* Herrick.
3. *Crenipecten Winchelli* (Meek) (c).
4. *Platyceras Hertzeri* Winch (r).
5. *Chonetes pulchella* Winch (rr).
6. *Rhipidomella* (*Orthis*), cf. *Michelina* L'Eveillé (c).

7. *Cryptonella eudora* Hall (rr).
8. *Camarotœchia marshallensis* (A. Winch) ? (rr)

The Allorisma shales No. IV contain the following species:

1. *Allorisma ventricosa* Meek (rr).
2. *Sanguinolites* (?) *obliquus* Meek (r).
3. *Sanguinolites œolus* Meek (r).
4. *Sanguinolites* sp.
5. *Camarotœchia marshallensis* (Win.) (?) or *C. Cooperi* Shum. (?)
6. *Allorisma Winchelli* Meek (c).
7. *Sanguinolites naiadiformis* Winch. (r).
8. *Prothyris Meeki* (Winch) (r).
9. *Spirophyton* cf. *crassum* Hall (c).
10. *Syringothyris cuspidatus* (Martin) (rr).
11. *Liopteria* sp. (rr).
12. *Discina* (*Orbiculoidea*) *pleurites* (Meek) (?) (rr).

Professor Andrews did not definitely indicate the boundaries of the Waverly conglomerate; neither did Professor Hicks those of the Black Hand conglomerate and Granville beds. The thickness of the conglomerate near Hanover was given as from 85 to 90 feet,[1] and that of the Granville beds as from probably 25 to 111 feet.[2]

The Fucoid layer (No. 4c) of Hicks' Granville beds is the same as the "Allorisma layer" of Professor Herrick's and No. 4 of the Havens section. Division No. 2 of Professor Herrick's, which he called the Middle Waverly or Kinderhook, was clearly defined by Conglomerate No. I at the base and Conglomerate No. II at the top,[3] and by its fossils correlated with the Kinderhook formation of the Mississippi valley. This formation is apparently quite well marked by these two conglomerate strata in the vicinity of Newark, and Professor Herrick identified Conglomerate II in sections from Ashland county to Sciotoville on the Ohio River,[4] and later states that the Allorisma shale is "very persistent and well limited, even when the Conglomerate (No.

[1] Am. Jour. Sci., 3d ser., Vol. XVI, p. 217.

[2] *Ibid.*, p. 218. The statement is not clear, and 85 feet possibly represents the minimum thickness.

[3] Bull. Denison Univ., Vol. IV, 1888, pp. 105, 106.

[4] *Ibid.* See sections on p. 102.

VOGELMEIER QUARRY, NEWARK, OHIO.

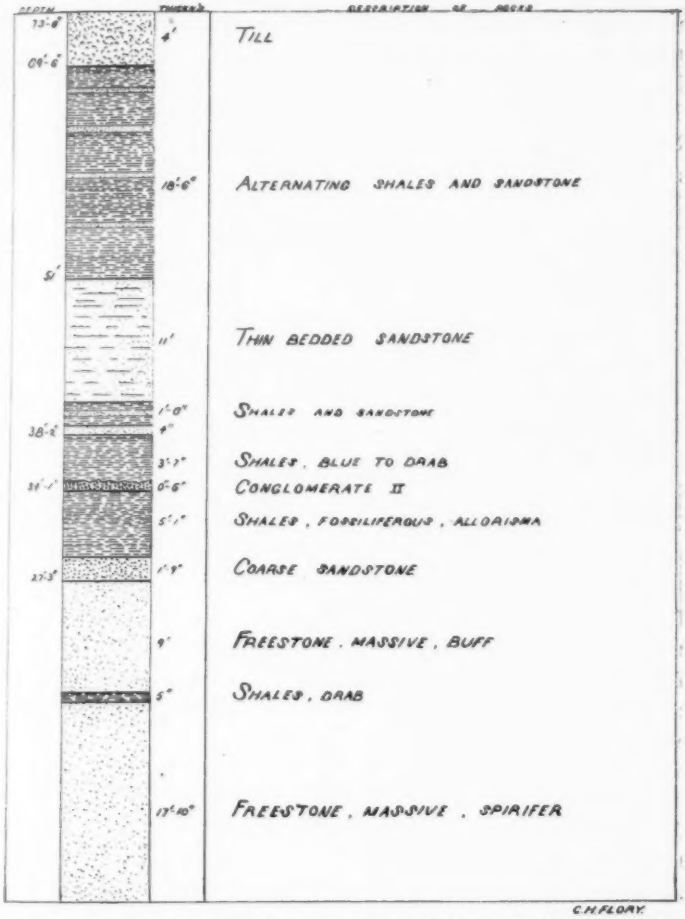

FIG. 2.—Section of Vogelmeier quarry, southeast of Newark, showing a part of the Black Hand and Logan formations. Conglomerate II is considered the line of division between them.

II) is absent, having been traced from Sciotoville to the northern exposures in Wayne county."[1] Conglomerate No. I seems less persistent than No. II, but below the freestone there are generally thick shales, so that the base of the formation is quite distinct stratigraphically.

In the vicinity of Hanover and in the gorge of the Licking River at Black Hand are excellent exposures of the conglomerate phase of the formation. Below Hanover, on the western

FIG. 3.—Ledge of Black Hand conglomerate below Hanover.

side of Rocky Fork, is a fine cliff of the conglomerate 80 feet high, which is shown in Fig. 3, while apparently its top, as shown by partial exposures in the field above the brow of the cliff, is some 35 feet higher. Professor Hicks gave the thickness of the Black Hand conglomerate at Hanover as from 85 to 90 feet,[2] and Professor Herrick reported that in the region about Clay Lick station, in Hanover township, "is a great development of the conglomeratic phase of the Waverly. One half mile east of Clay Lick there is a nearly continuous exposure of about 100 feet of alternating conglomerate and coarse sandstone of prevailingly red color."[3]

[1] Bull. Geol. Soc. America, Vol. II, 1891, p. 38.

[2] Am. Jour. Sci., 3d ser., Vol. XVI, 1878, p. 217.

[3] Bull. Sci. Lab. Denison Univ., Vol. II, 1887, p. 15.

To the east of the Hanover railroad station is a cut in which the contact of the Black Hand conglomerate and overlying Logan sandstone is nicely shown. To the south of the cut and highway is the quarry of the Hanover Pressed Brick Co. in the shales of the Logan formation. The section from the railroad to the top of the quarry is as follows:

		Thickness feet	Total thickness feet
No. 4.	Mainly blue to drab argillaceous shales with some bands of sandstones which vary from 7 inches to perhaps a foot in thickness -	20	92
3.	Covered - - - - - - - -	18	72
2.	Buff shaly thin bedded sandstones containing fossils which are well shown in the upper part of the railroad cut in the vicinity of the highway bridge. Lower part of the *Logan sandstone* which is separated by quite a sharp line from the massive grit to conglomerate below. There are some thin layers of conglomerate near the base of the Logan sandstone.	22	54
1.	Massive grit to conglomerate which forms the lower portion of the cut. Part of the rock is a buff grit and the remainder a conglomerate some of the pebbles of which are quite large.	32	32

BLACK HAND CONGLOMERATE

The Black Hand conglomerate named from the cliffs in the gorge of the Licking River, known as the Licking Narrows, begins a short distance above the station of Black Hand on the Baltimore and Ohio Railroad.[1] On the north side of the river rather more than a quarter of a mile above the bridge are two conspicuous cliffs, the lower one called Red Rock and the upper one Black Hand which is shown in Fig. 4. On the southern side of the river is a railroad cut which shows finely the contact of the Black Hand conglomerate and the Logan sandstone. To the west of the cut at a distance of about one half mile from the station is a prominent cliff in one part of which is the E. H.

[1] For a description of the topography of this region and the former as well as the present gorge of Licking River, see Professor W. G. Tight's paper in Bull. Sci. Lab., Denison Univ., Vol. VIII, Pt. II, pp. 36–43, and Pls. I, II.

Evertts & Co. quarry for glass sand. The following section was measured at this locality from the level of Licking River to the top of the cliff.

SECTION OF SOUTHERN BANK OF LICKING RIVER AT EVERTTS & CO. QUARRY

		Thickness feet	Total thickness feet
No. 6.	Till - - - - - - - - - -	7	101
5.	Thin, irregular bedded, drab or bluish sandstone and bluish argillaceous shales. In places at the bottom is a 3-inch clay shale resting on the massive conglomerate with a sandstone to conglomerate layer above. Lower part of the *Logan sandstone* - -	22	94
4.	A coarse conglomerate stratum at the top of the conglomerate which in places is 11 inches thick. The top of the *Black Hand conglomerate* - - - - - - - - -	1	72
3.	Gray to drab coarse grit, which in places is a conglomerate that is worked for glass sand. This forms the upper part of the main cliff -	21	71
2.	Coarse grit and conglomerate to the base of the cliff at the Crusher - - - - -	16	50
1.	Mostly covered bank below the Crusher but all in the conglomerate as shown by exposures a little farther down the river. Level of Licking River - - - - - -	34	34

6. *Logan formation* (sandstone) was named by Professor Andrews in 1870 from outcrops in Hocking county near Logan,[1] and was stated to overlie the conglomerate at Black Hand and to extend down the Licking Valley "to a point between Pleasant Valley and Dillons Falls."[2] This division was named the Licking shales by Professor Hicks, who states that they are well developed in the hills bordering Licking River from Newark to Black Hand, 100 to 150 feet in thickness, and "lie 70 to 80 feet above the water level, forming the middle of the slope of these hills, the base being composed of the massive Black Hand conglomerate and the upper slopes and summit of the various strata of the Coal

[1] Geol. Surv. Ohio, Part II, pp. 76, 79. [2] *Ibid.*, p. 79.

Measures."[1] This formation is Division 3, or the Upper Waverly of Professor Herrick, which he gave as 80 feet in thickness in Licking county and which, from the fossils, he correlated with the Burlington and Keokuk of the Mississippi valley.[2]

In 1888 Dr. Orton united the Waverly conglomerate and Logan sandstone of Andrews to form the Logan group.[3] If it

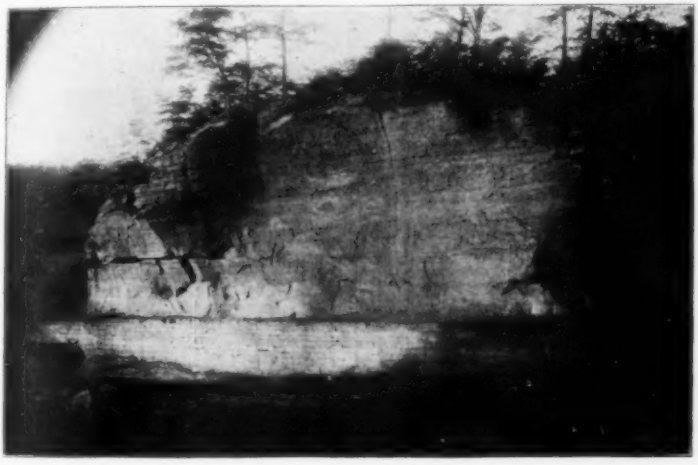

FIG. 4—Black Hand rock in the gorge of Licking River.

be advisable to make one formation of these two divisions, the above name is inappropriate because the Logan sandstone of Professor Andrews clearly referred to the upper division only, as has been noted by Professor Herrick.[4]

The above ruling is believed to represent the position of the United States Geological Survey, as shown by the following quotation from a recent letter of Mr. Bailey Willis, assistant in

[1] Am. Jour. Sci., 3d ser., Vol. XVI, 1878, p. 216.

[2] Bull. Denison Univ., Vol. IV, 1888, pp, 99, 100.

[3] Rept. Geol. Surv., Ohio, Vol. VI, p. 39.

[4] Bull. Geol. Soc. Amer., Vol. II, 1891, p. 38.

geology to the Director of the United States Survey and Geologist in charge of Areal Geology, to whom these questions in nomenclature are referred:

> The survey distinctly recognizes the right of priority, that is to say, the name first applied to a well defined geologic unit is to be preferred. The qualifying conditions, on account of which the name may be rejected and one of later application used, are (1) that the name has been previously applied to some other unit, and (2) that the unit to which the name was applied was not well defined.
>
> Thus, in the case which you cite, the term Waverly conglomerate (Andrews) would not hold if Waverly had previously been used for something else, and by application of the same rule Waverly series should be discarded if Waverly conglomerate had priority. The Logan group (Orton) should not stand as opposed to Logan sandstone.
>
> In these questions there is often a personal element which makes it a matter of regret that some desirable name should not be adopted, but we feel that the advantages of clearness and definition in science must be superior to such conditions, and that the rule should be rigidly applied.[1]

Dr. George H. Girty, of the United States Geological Survey, who has been engaged for several years in a thorough study of the stratigraphy and paleontology of the Waverly series in Ohio, Michigan, and Pennsylvania, concurs in regarding the upper part of the series in central Ohio as composed of two formations, as may be seen from the following quotation:

> I have seen the Logan group at Logan and vicinity and also at various points in Licking county. I quite concur with you in regard to the separateness of the two component members in central Ohio at least, and am in uncertainty as to the reasons which led Professor Orton to unite the two beds under a common name.[2]

The lower part of this formation is well shown in the Vogelmeier and Havens quarries, where Conglomorate II is succeeded by from 4½ to 6 feet of greenish-gray to bluish argillaceous shales, and these are followed by from 11 to 17 feet of quite massive buff sandstones, capped by alternating shales and sandstones, 18½ feet of which are shown at the top of the Vogelmeier quarry. There are fair exposures of the remaining part of the formation in "the gorge" to the east of the Havens quarry,

[1] Letter of December 18, 1900. [2] Letter of January 5, 1901.

partly in the bank of the creek and partly by the roadside, where 85 feet of buff arenaceous shales to thin bedded sandstones are shown. This gives about 115 feet for the thickness of the formation, which is capped by the Coal-measure conglomerate where the road and creek emerge from the woods. In sections farther to the south and southeast the top of the Logan sandstone is defined by the base of the sub-Carboniferous limestone, named by Professor Andrews the Maxville limestone.

CHARLES S. PROSSER.

COLUMBUS, OHIO,
December, 1900.

THE USE OF BEDFORD AS A FORMATIONAL NAME

In a paper about to be published by Professor Charles S. Prosser it will be stated that the "*Bedford shale* was named by Newberry in 1870[1] from outcrops east of Cleveland at which place, he later states, the best exposures occur." It will be further stated that the term "Bedford rock" as used by Owen[2] for a portion of the Sub-Carboniferous limestone of Indiana was evidently not intended as a formation name.

In the citation of Owen's use of the term Bedford rock lies the basis for the present use of the name Bedford for the Indiana formation. In the later reports of the Indiana Geological Survey, down to the Twenty-first Annual Report, the name Bedford is not applied to these rocks; but in the Fifteenth Annual Report the name Salem rock[3] is used, though not as a formation name, and again in the Seventeenth Report, Salem is said to afford the "best exposure for study [of the oölitic limestone] from the geologist's point of view."[4] In the Fifteenth Report (*loc. cit.*) a section of the Salem Stone and Lime Company's quarry one half mile west of Salem is given as follows:

Soil and rubbish	3 feet
Dark blue, bituminous limestone (bastard)	6 "
Gray oölitic quarry stone	30 "
Blue crystalline limestone	6 "
Total	45 feet

The oölitic character of the rock is said to be especially well shown in this section.

Since the term Bedford as the name of a formation is preoccupied, having been applied to the "Bedford shale" of

[1] Geol. Surv. Ohio, Part I, Rept. Progress in 1869, 1870, p. 21.

[2] Geol. Recon. Indiana, 1862, p. 137.

[3] Ind. Geol. and Nat. Hist., Fifteenth Ann. Rept., p. 143.

[4] Indiana, Dept. of Geol. and Nat. Resources, Seventeenth Ann. Rept., p. 47.

northeastern Ohio in 1870, the writer proposes the name *Salem limestone* for the rocks called Bedford limestone by Hopkins and Siebenthal.[1] The so-called bastard limestone of the quarrymen is to be considered as the base of the formation next above (Mitchell); and the base of the Salem formation is to be taken at the top of the Bryozoal limestone that throughout its entire extent constitutes the upper zone of the Harrodsburg limestone as defined by Hopkins and Siebenthal.[2]

In suggesting a different name for the rocks under consideration the writer is aware of the claims of Spergen hill. The latter place is, however, chiefly known as having afforded the extensive series of fossils described by Hall[3] and later redescribed and figured by Whitfield,[4] and is not so good a place for studying the stratigraphic relationships of the formation as a number of other localities. Moreover, the Spergen hill fauna is confined to parts of the formation, and in many localities would be of scarcely any service in identifying it. The oölitic character of the rock, on the other hand, while more pronounced at some places than at others, everywhere serves as a means of identification and is the character that is especially well developed at Salem. Finally, as indicated above, the name Salem has been associated with the oölitic limestones in the Indiana reports since 1885.

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[1] Indiana, Dept. of Geol. and Nat. Resources, Twenty-first Ann. Rept., 1896, p. 298.

[2] *Ibid.*

[3] Trans. Alb. Inst., Vol. IV; Indiana, Dept. Geol. and Nat. Hist., Twelfth Ann. Rept.

[4] Bull. Am. Mus. Nat. Hist., Vol. I, No. 3.

ON THE USE OF THE TERM BEDFORD LIMESTONE

It has not been the custom of the Indiana geologists to give local geographic names to geologic formations, and previous to the twentieth report of the state geologist (for 1895) but three or four formations had been so described. The earlier geologists were content to correlate the rocks with the formations of adjoining states and use the names already in use.

The business of quarrying the oölitic limestone grew up at a number of points. The quarry rock was recognized to be equivalent but was not known to be continuous. It was thought to exist in "deposits." Each locality was jealous of the qualities of its "deposits." So we had *White River stone*, *Elletsville stone*, *Bedford stone*, *Salem stone*, etc. In the course of time the greater development of the quarries at Bedford caused that stone to dominate the others in the market, and the Indiana oölitic limestone came to be generally known as *Bedford stone*, and as such, it has been specified by architects in more than thirty states. Its reputation having become thus established, all localities were willing to have their stone known as *Bedford stone*, and geologists were no longer embarrassed by local rivalry in giving this name to the formation.

Dr. R. T. Brown, state geologist, in a "Geological Survey of the State of Indiana," published in 1854,[1] gives a section of the rocks at the railway cut near Harristown (presumably that celebrated later as Spergen Hill), recognizing the quarry ledge with its characteristic fossils to be equivalent to that quarried at Bedford, and the same as that shipped from the northwestern part of Monroe county as *White River stone*.

Richard Owen[2] in 1862 used the term *Bedford rock*, referring to stone quarried from the formation in question at Bedford. It

[1] Transactions of the Indiana State Agricultural Society, 1853, pp. 311, 312.

[2] Geological Reconnoissance of Indiana, 1862, p. 137.

may be noted here that in the Bedford region the formation is practically homogeneous and is quarried from top to bottom.

The reports of the Indiana Survey for 1869, 1870, and 1872 deal exclusively with the coal deposits. The report for 1873 mentions *Bedford stone* on pages 276, 280, 282–284, and 312. The report for 1874 does not touch upon the formation. The report for 1875 alludes to the oölitic limestone of Owen county as *white quarry stone*. In the report for 1878 an analysis of stone from Bedford is referred to in the index as *Bedford stone*.

The reports from 1880 to 1895 inclusive speak of this stone as Indiana oölitic limestone, though that from Bedford is called Bedford stone (1881, p. 31), and, as mentioned in the preceding article, that from Salem is called *Salem stone* (1885–6, pp. 143–146). So, too, it had been called *Salem stone* in the preceding report (1884, pp. 76–78).

In the report by T. C. Hopkins and the writer (1896, pp. 289–427) the oölitic limestone of the different quarries was for the first time shown to be not only equivalent but actually continuous. A single name became imperative. It was at hand. The name *Bedford oölitic limestone* was adopted rather than proposed as a new name. To have proposed a name would have raised the question of priority, and *White River limestone* would clearly have been entitled to precedence. Under the title *Bedford stone* this limestone was as well known as a geologic formation can be, over more than half the United States. The term which had been originally applied to the whole formation at one place was now extended to the formation throughout its extent.

We think that these facts justify the prior claims of Indiana to Bedford as a formation name, and that it will not be necessary to drop the term. But drop it we could not if we would, for, to the trade, *Bedford stone* it will be to the end of the chapter.

C. E. Siebenthal.

NITRATES IN CAVE EARTHS

A NEW theory of the origin of nitrates in cave earths has been recently propounded by Mr. William H. Hess (JOUR. GEOL., Vol. VII, p. 2) who considers that they are the product of the nitrifying bacteria in the soil above, and that they enter the cave with the seepage through the roof and are deposited by the total evaporation of the water in the dryer parts of the cave. In other words the dry galleries and chambers of a cave serve as a gigantic natural still, catching the seepage from the surface and retaining the solids. Inasmuch as the older theory that these nitrates are leached from the bat guanos formed in the caves is on the face of it sufficient to account for the facts while difficulties arise in the application of the new theory a comparison would seem to be in order. The first and most serious objection Mr. Hess urges against the older theory is a statement that bats never go far from the mouth of the cave, while many analyses (not quoted) show that the nitrates are distributed through the dry chambers of the cave. This would seem to be decisive if rigorously verified, for if bats never went far from the entrance it would be exceedingly difficult to account for the presence of derivatives of bat guano in all dry portions of the cave. In reality, bats frequent in very large numbers remote portions of caves. Dr. O. C. Farrington, in a recent expedition through the caves of Indiana, found bats in all parts of the caves visited.[1] Mr. Hess' second objection is that the cave earth contains little or no organic matter. Two specimens in the collections of the Field Columbian Museum, one from Indiana and one from South America do contain organic matter visible on casual inspection. As the niter, according to the general opinion, is for the most part not a decomposed or altered guano but a residual clay or sand impregnated with soluble salts by seepage from bat guano, there is no reason why it should

[1] Field Columbian Museum Publication 53, p. 244.

contain insoluble organic matter or more organic matter than is indicated by the amount of nitrogen and chlorine shown by Mr. Hess' analyses. This objection, apparently based on inspection of the specimens and a single analysis, cannot therefore be considered proven. The third objection made by Mr. Hess to the origin of nitrates in the cavern itself is that while the cave earth and the bat guano contain approximately equal quantities of phosphates, the soluble phosphate is much less in the underlying earth than in the overlying guano. This, however, is merely an illustration of a phenomenon with which all phosphate manufacturers are familiar, viz., the "reversion" of the soluble to the insoluble phosphate by virtue of which a very large percentage of the "available" or soluble acid calcium phosphate of a "superphosphate" when applied to the soil, changes to various insoluble phosphates.[1] It does not appear, then, that any of the above objections are in any sense conclusive.

In support of the external origin of the nitrates, Mr. Hess calls attention to the fact that the leachings from the surface subsoil contain nitrates in small quantity. He also attempts to show by analyses that the soluble portions of the niter earth might be the concentration of the leachings from surface soils, although the figures he gives appear to prove the reverse. Inasmuch as both the niter earth and the surface soil are both (in the Kentucky and Indiana caves) residual soils from limestone, contaminated with organic matter, a general similarity in consequence of similarity of origin is to be expected and is found. But if the soluble salts of the niter earths are the soluble salts transported from the overlying soil, more than a general resemblance should appear. After due allowance is made for compounds which will not redissolve the two should be practically identical if the analyses correctly represent the average constitution of the mixtures in question. As printed, Mr. Hess' analyses do not admit of ready comparison. If the analysis which he gives (p. 131) of subsoil over Mammoth Cave and of the cave earth directly below are recalculated so as

[1] WYATT: Phosphates of America.

to indicate the percentage composition of the soluble portion (on the assumption that the analyses are complete) they compare as follows:

SALTS LEACHED FROM SUBSOIL AND FROM CAVE EARTH, MAMMOTH CAVE

	Na_2O+K_2O	CaO	SO_3	P_2O_5	N_2O_5	NH_4
1. Subsoil.	15.32	9.58	28.72	tr.	36.17	10.21
2. Cave earth.....	28.94	20.54	42.10	0.003	8.30	00.001

The resemblance is purely qualitative, and it is very evident that the second substance could not be formed by the evaporation of a solution of the first as the theory requires. The water which enters the cave forms stalactites and stalagmites and, therefore, must carry carbonate of lime. In the aqueous extract from the subsoil, considered below, the bases are saturated with nitric and sulphuric acid and hence it contains no carbonates. This analysis therefore does not represent the waters which enter the cave. It is most probable that these waters after leaving the subsoil take up carbonate of lime and other material while passing through the rock roof and enter the cave with the composition of the drip water whose analysis is given by Mr. Hess (*loc. cit.*, p. 132).

From the analysis of waters dripping into Mammoth Cave made by Mr. Hess, the figures below have been derived calculating the ratio of certain salts for comparison with the soluble salts from the cave earths of Mammoth and Saltpeter Caves, also recalculated from Mr. Hess' analyses.

SALTS LEACHED FROM CAVE EARTH COMPARED WITH CORRESPONDING SALTS FROM DRIP WATER

	K_2O+Na_2O	CaO	SO_3	P_2O_5	Cl	N_2O_5	NH_4
Certain salts from drip water, Mammoth Cave.....	23.24	42.37	22.18	tr.	3.83	8.06	0.06
Cave earth, Mammoth Cave..	27.23	19.91	40.56	.....	5.26	6.95	0.09
" " " "	22.39	23.56	33.65	.....	10.38	10.01	0.007
" " Saltpeter Cave...	22.62	23.13	33.03	.....	2.30	18.82	0.07

From this table it is evident that solids from the drip water contain practically twice as much lime as those from the cave earth and much less sulphates and chlorides. Exact calculations for the saturation of bases by alkalies cannot be made without knowing the ratio of soda to potash. An inspection of similar determinations for many Kentucky soils shows for similar situations a ratio of potash to soda of 1 : 4. Assuming this ratio, then, in the case of the drip water, after all the acids are saturated there is a large excess of lime left. This holds true both for the salts given in the above table and for the full analysis as given by Mr. Hess. This lime is held as carbonate and would be deposited as calcite upon evaporation. But in the salts extracted from the cave earths, as before noted, we find that the acids nearly saturate the bases and there is little lime left as carbonate. While the quantities will change as we assume more or less soda in the mixed alkalies, yet the proportions do not vary to any important degree, and in any conceivable case there is a very large excess of calcite in the drip water unaccounted for in the cave earth. In short, the drip in Mammoth Cave carries chiefly carbonates, while the cave earths carry chiefly sulphates. For the drip water to deposit any nitrate it is necessary that it should evaporate practically to dryness and deposit essentially all of its lime and other salts. For every 8 parts of nitric acid, 42 parts of lime will be deposited, and thus the deposit would take the form of stalagmite enclosing the clay or sand, a form of deposit actually found in places but not forming any portion of the cave earth.

The removal of nitrates from guano to cave earth is different. The drip becomes saturated with salts while passing through the guano, deposits only part of its burden in the underlying cave earth, and drains off with the remainder. The deposits thus formed will be composed chiefly of the more soluble instead of the less soluble salts, and no stalagmite will form. This may be made more evident by assuming an ideal case. Take 1 liter of water saturated with calcium nitrate, calcium carbonate, and carbonic acid at 54° F. Keeping the temperature constant, let

the water evaporate until only ¾ liter remains. One liter of water at 54° F. will hold in solution approximately 1100 grams of calcium nitrate[1] and (disregarding the influence of the calcium nitrate) only 0.88 gram of calcium carbonate.[2] When reduced to ¾ liter by evaporation it will hold only 825 grams of calcium nitrate and 0.66 gram of calcium carbonate. If the solution be now removed, there remains a precipitate of 275 grams of calcium nitrate and only 0.22 gram of calcium carbonate. This applies to all cases of soluble with slightly soluble salts except where chemical actions intervene, as in the case of phosphates. In one specimen from Dixon's Cave the analysis of the cave earth, recalculated below, shows a very large excess of carbonates. In this case the amount of soluble salts is very minute (0.5655 per cent.), and we probably have the beginning of a stalagmite deposit forming in the nitrates. Over 90 per cent. are bases, with only 5½ per cent. of sulphuric acid. There is no analysis of dropping waters for comparison in this case, however.

SALTS LEACHED FROM CAVE EARTH AND OVERLYING BAT GUANO, DIXON'S CAVE.

	$NaO_2+{}_2KO$	CaO	SO_3	P_2O_5	Cl	N_2O_5	NH_4
1. Bat guano, Dixon's Cave.....	3.50	31.68	6.35	0.42	—	57.08	0.97
2. Cave earth underlying 1	45.98	40.67	5.48	2.42	—	2.09	3.36

As the overlying bat guano in this case yields up to water salts of which over 57 per cent. are nitric acid, it is difficult to understand how a water carrying the traces of nitrates from the surface of the earth could penetrate this guano to the underlying cave soil without taking along much more nitric acid from the bat guano than the almost infinitesimal quantities it brings from the surface. In this case the soluble part of the deposit is undoubtedly a mixture of the matter in the drip and the matter leached from the bat guano, and there is a bare possibility that

[1] OSTWALD: Outlines of Theoretical Chemistry, p. 150.

[2] ROSCOE and SCHORLEMMER: Treatise on Chemistry, Vol. II, Pt. I, p. 209.

a very small quantity of nitrate from the surface may be mixed with the much larger quantity leached from the bat guano above.

There are, however, better indicators than the carbonate or sulphate of lime. These are chlorine and the phosphates. The chlorine has not been given in a sufficient number of Mr. Hess' analyses to be available in this discussion, but the data regarding the phosphates are more complete. Inasmuch as phosphates "revert" or become insoluble, the total phosphate, not the soluble, must be considered. Mr. Hess finds only traces of phosphate in the drip or in the soluble extract from the soils of the surface, while the quantity of phosphoric acid in the guano and the niter earth is approximately equal and is very considerable, 2.62 per cent. and 2.10 per cent. respectively. While the approximation to equivalence is doubtless accidental, yet it is undeniable that there is in cave earth much more phosphate in proportion to the niter, alkalies, etc., than the drip water could bring in. An abundance of phosphate is found in soluble form in the bat guano. Mr. Hess regards this excess of phosphate as a concentration in the residual soil, of the calcium phosphate of the limestone on account of its insolubility. But it appears from the figures given by Penrose and others[1] that the percentage of phosphate of lime in limestone and in its residual clay is approximately the same, the larger part of the phosphate going into solution with the carbonate of lime. Penrose selected clay from a hollow in the limestone where it was overlain by 15 feet of similar clay and a chert cap, and compared it with the limestone. He found phosphoric acid in the limestone 3.02 per cent. and in the clay 2.53 per cent. It is not contended that under exceptional circumstances phosphates may not be concentrated as a residuum after solution of limestone, as Safford claims for those of Tennessee, but it is contended that such concentration, if it occur at all, is very unusual, and furthermore that it does not occur in the cave regions of Kentucky and Indiana.

Although no determinations of phosphoric acid in limestone and its residual soil can be found for the immediate vicinity of

[1] MERRILL: Rocks, Rock Weathering, and Soils, p. 232.

Mammoth and the other caves considered, yet the above conclusion may be confirmed for the State of Kentucky by the following figures from the analyses of rock and soil made for the Kentucky Geological Survey.[1]

No.	Substance.	P_2O_5, per cent.
570.	Subsoil	0.440
571.	Red underclay	0.425
572.	Limestone	0.221
573.	Limestone	0.196
576.	Subsoil, Bourbon county	0.243
577.	Underclay	0.221
578.	Limestone	0.093
579.	Limestone	0.183
614.	Subsoil	0.316
615.	Limestone	0.311
663.	Virgin soil, Jessamine county	0.239
664.	Virgin soil, Jessamine county	0.666
666.	Limestone	0.567
683.	Subsoil	0.459
684.	Underclay	0.456
685.	Limestone	0.631

In preparing the above table all cultivated soils have been excluded, and it is believed that only examples of virgin soils, subsoils and underlying limestones that are properly comparable have been included. The average of these figures is 0.315 per cent. P_2O_5 for the limestones and 0.365 per cent. P_2O_5 for the soils. The average of twenty-five analyses of subsoils overlying limestone in Kentucky is 0.264 per cent. P_2O_5. Mr. Hess finds 2.62 per cent. P_2O_5 in bat guano and 2.10 per cent. P_2O_5 in cave earth. This is obviously a far greater proportion of phosphate than is found in other residual clays, and as in the drip water he finds only a trace of phosphate with 53.61 milligrams carbonate of lime, the difference can hardly be made up from that source. On the other hand, the bat guano provides an abundant supply, as all the phosphorus used in the metabolic processes of bat life must eventually find its way to the guano. Finally, it

[1] Third Report Geol. Surv. Kentucky.

may be noted that Mr. Hess' claim that nitrates are uniformly distributed in the dry chambers of caves is not substantiated by the analyses of cave earths of Wyandotte Cave made for the Indiana Geological Survey.[1] Besides the analysis of niter earth, there is given one of the magnesian earth which is abundant in the dry portions of Wyandotte Cave. The analysis of this earth shows no nitrates. An interesting variation between the distribution of nitrates and of other nitrogen compounds throws much light upon the problem, and has been investigated by Müntz and Maracano for some Venezuelan caves.[2] "There is thus a gradual change in the character of the nitrogenous combination from the interior to the exterior portions of the cave, as shown in the following analyses:

Constituents	Guano from interior of cave	Earth from entrance	Earth some distance from entrance
Organic nitrogen	11.74 per cent.	2.41 per cent.	0.80 per cent.
Nitrate of lime	0.00 "	3.03 "	10.36 " "

If the transformation of organic nitrogen through ammonia and nitrites to nitrates by the action of bacteria occurs only at the surface, there should be no uniform variation in the proportions of these components in the cave earths, but such a variation as has been found might occur from the mouth of the cave inward if the bacteria are acting in the cave itself. Mr. Hess has doubtless performed a service in pointing out a method by which cavern deposits of nitrates may be formed, and it is not improbable that such deposits may be discovered. Deposits thus formed, however, will have several easily recognized features not found in the cavern earths now known.

HENRY W. NICHOLS.

FIELD COLUMBIAN MUSEUM,
March 2, 1901.

[1] Indiana Geol. Surv., 1878, p. 162.

[2] MERRILL: Rocks, Rock Weathering, and Soils, p. 372.

DERIVATION OF THE TERRESTRIAL SPHEROID FROM THE RHOMBIC DODECAHEDRON

Two papers have recently been published which tend to again awaken special interest in the theme of the grand plan of the earth. One is the presidential address of Professor B. K. Emerson on the "Tetrahedral Earth and the Zone of the Intercontinental Seas," delivered before the Geological Society of America; and the other is a lecture before the Royal Geographical Society by Dr. J. W. Gregory, on the "Plan of the Earth and Its Causes."

Both papers are an explanation and discussion of the quaint and suggestive conception of the tetrahedral form of the earth as advanced by William Lothian Green, an English merchant of Honolulu, an original thinker of no mean astuteness, who, in his *Vestiges of the Molten Globe*,[1] presents a hypothesis which can be, by no unbiased student, regarded as lying entirely within the fanciful.

Briefly stated, Green's hypothesis is that on the theory of a cooling globe, a noticeably angular or ridged form would result. As the sphere is the solid which contains the maximum volume under a given surface, so the geometrical form having the minimum volume under the same surface is the tetrahedron. Hence, the contracting globe would tend to assume the tetrahedral shape, as one permitting the greatest reduction of bulk with the least amount of change of surface.

Green takes as his fundamental form the hexatetrahedron with curved faces, as most nearly approaching the sphere. In the development of the hemihedral form of the hexatetrahedron the original faces retained give rise to one set of obtusely pointed pyramids; and the extended portions of the faces a second set of pyramids having more acute apices. The former represent the water areas of the globe and the latter the land

[1] Vestiges of the Molten Globe, Pt. I, London, 1875; Pt. II, Honolulu, 1887.

areas. There are then three triangles of water with their bases against a land triangle around the south pole, pointed northward and interlocked with three great southward-pointing land triangles, having their bases against the north polar triangle of water. Thus is explained the plan of the earth as indicated by its grandest geographic features.

The idea of a tetrahedral earth did not first originate with Green, though it was doubtless original with him. Neither is the attempt to reduce the earth to a faceted body unusual. From the time of Élie de Beaumont, more or less intense interest has been taken in the subject.

The distinctly tetrahedral conception has been, as Professor Emerson has noted, discussed by a number of writers. Richard Owen,[1] of New Harmony, Indiana, and brother of Dr. David Dale Owen, compared the form of the earth to the crystal of diamond. Besides Green, already mentioned, Michel-Lévy[2] has lately formulated his tetrahedral idea of the earth. Still more recently Gregory[3] has considered the subject much along the same lines as the writer last mentioned.

In comparing Green s tetrahedron with that projected by Michel-Lévy it may be noted that the obtuse pyramids of the former correspond very nearly to the sharp pyramids of the latter.

Now, the main object of the present note is to call attention to the fact that in all of these more recent attempts to reduce the earth to regular geometrical form there is an important suggestion that appears to have escaped notice. This is embodied in a short paper which appeared in the *American Meteorological Journal* for 1888,[4] under the title of the "Probable Derivation of the Terrestrial Spheroid from the Rhombic Dodecahedron." It is by the same Richard Owen who earlier gave expression to many of the facts and fancies connected with the idea of the tetrahedral earth.

[1] Key to the Geology of the Globe, p. 60, 1857.

[2] Bull. Géol. Soc. France, T. XXVI, p. 105, 1898.

[3] Geographical Journal, Vol. XIII, p. 225, 1899.

[4] Am. Meteorological Jour., Vol. V, p. 289, 1888.

The polar axis of the earth is regarded by Owen as extending from the center of one rhombic face to the center of the opposite one. The sharp, four-sided axial angles of the dodecahedron are near the Aleutian Islands, New Zealand, and, on the earth's equator, at Sumatra and Quito; while the remaining two lie in the Alps and south of the Cape of Good Hope. Thus oriented the following propositions are formulated:

1. Centers of rhombs are usually occupied by water or low land;

2. Ridges of rhombs usually give rise to mountains, and river sources; also sometimes to parallel valleys with important rivers;

3. Many of the apices are characterized by vicinity of volcanic groups;

4. Rhombs facing each other have considerable similarity in the distribution of land and water;

5. Daily rotation and annual revolution seem to have determined the configuration of land.

How closely these generalizations accord with facts may be easily tested by reference to any school globe. Why Owen should have oriented the dodecahedron just as he did does not appear. It would seem that in all cases of this kind the starting point which is first selected has much to do with subsequent developments. In Owen's case the depression of the Arctic Ocean offered the schematic rhomb. Then, too, the Mediterranean area required special attention. So important is the last named region that Michel-Lévy, in his plan, was led to make it a point where three polar edges of his tetrahedron should meet.

If there be anything in the idea of a collapsing crust on a shrinking interior, the tendency of the surface toward the assumption of any angular form would find adequate reason in an adjustment which would produce as nearly as possible the least amount of deformation in the lithosphere compared with the amount of change in the bulk of the earth. This geometrical shape is, as already noted, the tetrahedron; but a four-sided figure in which

each face would be of the most general form — that is, with six facets — curved after the manner of the diamond.

But while the natural tendency, in a collapsing shell, may be to assume a form affording the least change of the surface, extraneous conditions might impose slight modifications in other directions. The resultant form might then be a closely similar shape, having the same symmetry. As related to the hexatetrahedron, the rhombic dodecahedron is one of these forms. And Owen's scheme may more nearly correspond with observed facts than any plan based upon the strictly tetrahedral conception.

In any case, we should expect to have the great world ridges follow approximately the geometrical edges of whatever form is selected. In the central portions of the faces we should expect to find, on the whole, marked depressions. If these features are to be regarded as essential criteria, then Owen's scheme appears to offer fewer objections than any yet suggested. In these considerations the hydrosphere may be practically neglected.

The rhombic dodecahedron is a schematic form to which the great features of the earth are capable of even more exact adjustment than that proposed by Owen. If the dodecahedron be oriented so that one of its axes coincides with the earth's axis of rotation, the ends of the other two axes may be made to intersect the earth's equator where the latter passes through Sumatra, the west coast of Africa, the west shore-line of South America, and the Phœnix Islands, in the central Pacific Ocean. There will then be grouped around the north pole of the earth four rhombic faces as follows:

1. North American,
2. European,
3. Asian,
4. Bering.

Around the equator are:

5. Northern Pacific,
6. Atlantic,
7. Indian,
8. Eastern Pacific.

About the south pole are arranged:

9. South American,
10. South African,
11. South Indian,
12. South Pacific.

The great Cordilleran ridges of North America, from near the extremity of South America to the Arctic Ocean lie directly on the edges of the dodecahedral form. The line is marked by a remarkable succession of volcanoes both active and only recently extinct. Greenland lies on another of the polar edges of the northern zone of rhombs. Another remarkable world-ridge passes down on rhombic margins from Franz Joseph land, through Novaya Zemlya, the Urals, the Himalayas, Sumatra and the Sunda Islands, Australia to Tasmania. Between the last named place and the south pole is Wilkes Land and Victoria Land, with the active volcano Erebus near the line.

From Sumatra, northeastward extends the most wonderful line of active volcanoes known on the globe — the line bordering the east coast of Asia. From Japan a north polar edge is continued in the long island of Saghalien, certain chains of northeastern Siberia, and farther north in the Arctic Ocean by the Liakov Islands.

Other mountain ridges and groups of active volcanoes characterize most of the other edges of the dodecahedron, frequently in a very notable way.

The only apparently incongruous element in the scheme is Europe. But this comparatively high land has its antipodal representative rhomb in the deepest south Pacific.

However fanciful the speculations of this kind may be regarded, it is certain that mountain ranges are susceptible of systematic arrangement. Moreover, mountain ranges must be considered as having different taxonomic ranks according to their genetic origin.

We know that the smaller folds of the earth's strata are complex, that little ones may ride, as it were, on larger ones, and that these again may rise out of still greater swells. Structural

mountains may be thus likened to the waves of a tempestuous sea, and, within each province of the mightiest rolls, may be arranged in harmony with their taxonomic relationships.

The master earth ridges may have one origin, and be arrayed —not in sharply defined geometric figures, perhaps—but in accord with definable laws. Within the grand provinces defined by these greatest features, mountain ranges may be determined by wholly different causes—possibly in out-flowing, curved elevations, something after the manner suggested by Suess for Siberia. Parts of these systems may again be modified by still more local causes—being intensified in some places, softened in others.

In the consideration of mountains, as features of the earth's face susceptible of giving expression to its deepest emotions, we have to recognize fully, before we can hope to understand the riddle of their existence, that all do not possess the same taxonomic values.

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DES MOINES, IOWA.

THE VARIATIONS OF GLACIERS. VI.[1]

THE following is a summary of the Fifth Annual Report of the International Committee on Glaciers :[2]

RECORD OF GLACIERS FOR 1899

Swiss Alps.—As we approach the end of the century the advance of a number of glaciers which began in 1875 has gradually died out. Only one glacier was known to be advancing in 1899; nine were doubtful, and fifty-five were certainly or probably retreating.[3]

Eastern Alps.—During 1899 Drs. Blumcke and Hess published an important paper on the Hintereis glacier containing observations of the movement, melting, and interior temperature of the glacier, and an excellent map.[4] During the time of observation, in the summer, the temperature to a depth of forty meters was found to be practically the melting temperature.

The Vernagt glacier continues to advance; during the last year its velocity at a certain point has increased from 178^{m} per year to 280. Since it has been under observation (1889–1899) its velocity has increased to fifteen times its original value. The ice has thickened and the glacier is advancing.[5]

Of the glaciers observed in the Eastern Alps, fifteen are

[1] The earlier reports appeared in this JOURNAL, Vol. III, pp. 278–288; Vol. V, pp. 378–383; Vol. VI, pp. 473–476; Vol. VII, pp. 217–225, and Vol. VIII, pp. 154–159.

[2] Archives des Sciences Phys. et Nat., Vol. X, pp. 1–20. Geneva 1900.

[3] Report of PROFESSOR FOREL.

[4] Untersuchungen am Hintereisferner. Wissensch. Ergans. z. Zeit. des D. u. O. Alpenvereins. 1. Bd. 2. Heft.

[5] A very complete account of this glacier was given by PROFESSOR S. FINSTERWALDER in the Wissensch. Erganzunghefte zur Zeits. des D. u. O. A–V. 1. Band, 1. Heft, Graz 1897. This important paper contains a history of the remarkable variations the glacier has suffered, and an excellent discussion of the nature of the movement of the ice and the origin of moraines.

advancing, thirteen are stationary, and more than twenty-two are retreating.[1]

Italian Alps.—Eight glaciers show a retreat and two an advance.[2]

French Alps.—The Société des Touristes du Dauphiné has recently published an important book on the glaciers of Dauphiné.[3] The conclusions are as follows:

As a rule the glaciers of this region have been in retreat during the second half of the nineteenth century, but some became stationary and a few even advanced between 1889 and 1893. Of the glaciers under observation twenty-four are in retreat and two are stationary. One of these, the glacier Blanc, is remarkable; it advanced before 1865, was in retreat from 1865 to 1886, and then began an advance which has continued until 1899; during this period the glaciers nearby were in retreat, though a few of them showed an advance for a short time. Three glaciers at present show a thickening which may result in an advance.

Swedish Alps.—The Mika glacier has been stationary since 1897. Observations have shown a velocity of 18.3^{cm} a day in summer, whereas the mean for the year is 7.6^{cm}.[4]

Norwegian Alps.—A number of glaciers have been under observation and show in general a very slight retreat. The western glaciers of Jotunheim advanced during the summer of 1898. During the last few years a small snowfall and much heat is reported for this region and these glaciers are again in retreat.[5]

Greenland.—Photographs of the small Kiagtut glacier, near Julianehaab, show a retreat of several hundred meters between 1876 and 1899. A small glacier on the island of Disko retreated 46^{m} between 1890 and 1891.[6]

[1] Report of PROFESSOR FINSTERWALDER. [2] Report of Mr. OLINTO MARINELLI.

[3] Observations sur les Variations des Glaciers et l'Enneigement dans les Alpes dauphinoises; edited by Professor W. Kilian. Grenoble, 1900.

[4] Report of DR. SVENONIUS.

[5] Report of DR. OYEN. [6] Report of DR. STEENSTRUP.

Canada.—The Victoria glacier, near Lake Louise, Alberta, is retreating though no measures have been made.

Photographs of the Asulkan glacier, British Columbia, show no changes between 1898 and 1899. A small glacier on the southern side of Mt. Sir Donald has become smaller.

The Illecellewaet glacier has been observed with more or less regularity since 1887, during this time it has apparently retreated on the average 15.8^{m} a year. There are indications that it was stationary or advancing before 1887. It retreated 4.9^{m} between 1898 and 1899. In August 1899 the velocity of the ice close to the end was 13.7^{cm} a day; 460^{m} further back and near the middle of the breadth it was 17.2^{cm}. The upper part of the glacier seems to be growing thicker.[1]

Russian Asia.—The report gives the locations of a number of glaciers, many of which show undoubted signs of retreat.[2]

Himalaya.—Mr. Freshfield has induced the government officials to undertake regular observations of some glaciers. He found the glaciers of Kindjinjanga advancing slightly after having suffered an insignificant retreat. In general there are no indications of any important changes among those glaciers in recent years.

REPORT ON THE GLACIERS OF THE UNITED STATES FOR 1900[3]

The small glaciers in Montana continue to retreat.

A small glacier has been discovered on Mt. Arapahoe in

[1] Report of MESSRS. G. and W. S. VAUX, JR. See papers by the same authors: Some observations on the Illecellewaet and Asulkan Glaciers of British Columbia. Proc. Phil. Acad. of Nat. Sci., 1899, pp. 121–124.

Additional Observations on Glaciers of British Columbia. Proc. Phil. Acad. Nat. Sci., 1899, pp. 501–511.

The Glacier of the Illecellewaet. Appalachia, 1900, Vol. IX, pp. 156–165.

ALBRECHT PENCK, translated by D. R. Keys: The Illecellewaet Glacier in the Selkirks. Proc. Canadian Inst. 1900, pp. 57–60.

[2] Report of MR. MOUSCHETOFF.

[3] A synopsis of this report will appear in the Sixth Annual Report of the International Committee. The report on the glaciers of the United States for 1899 was given in this JOURNAL, Vol. VIII, pp. 154–159.

Colorado.[1] The only other glacier known in this state is the Hallett.[2]

The Eliot glacier on Mt. Hood, Washington, is retreating and growing thinner (*H. D. Langille*). This means that the retreat will probably continue for some years and at an increasing rate.

On September 3, 1899, an earthquake shook the Alaskan coast and caused a large quantity of ice to be broken from the ends of tide-water glaciers. Glacier bay was so full of ice during the summer of 1900 that the steamers which usually visit that region were unable to approach Muir glacier nearer than four or five miles, and no satisfactory estimates could be made of the retreat of the glacier.

The Windom glacier, which ends on gravel-deposits in Taku inlet, is reported to have suffered the loss of a large part of its end, due apparently to the washing out of the supporting gravels.

Miles glacier, near the Copper River, Alaska, shows a marked recession since last year (*A. C. Spencer*).

The United States Geological Survey has published a large volume on "Explorations in Alaska in 1898.[3] Several parties were sent to explore various routes from the coast to the interior and, although no especial attention was given to the study of the glaciers, sufficient observations were made to bring out some interesting facts; many glaciers are cursorily described and their locations shown on the maps. The Alaskan glaciers are all of the valley or Piedmont types; Alaska was never under a great ice sheet like the eastern part of North America. The glaciers in the mountainous regions to the north, east, and southeast of Cook's Inlet, many of which are very large, were formerly much more extensive than now, and show evidences of continued

[1] The Glacier of Mt. Arapahoe, Colorado, WILLIS T. LEE: This JOURNAL, Vol. VIII, pp. 647–654.

[2] F. H. CHAPIN: Appalachia, Vol. V. p. 1; and Mountaineering in Colorado, p. 97.

[3] Twentieth Ann. Rept. U. S. Geol. Surv., Part VII. See also ABERCROMBIE: The Copper River Exploring Exped. Washington, 1899.

retreat. Whereas the glaciers to the west and southwest of Cook's Inlet are small and, though retreating, they were never much larger than at present (*Spurr*, *Mendenhall*, *Eldridge*).

Professor I. C. Russell has published an account of the former and present glaciation in northern Washington.[1] A synopsis of the existing glaciers in this region was given in an earlier report of this series.[2]

HARRY FIELDING REID.

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JOHNS HOPKINS UNIVERSITY,
March 15, 1901.

[1] I. C. RUSSELL: A Preliminary Paper on the Geology of the Cascade Mountains in Northern Washington. Twentieth Ann. Rept. U. S. Geol. Surv., Part II.

[2] This JOURNAL, Vol. IV, pp. 222–224.

PRODROMITES, A NEW AMMONITE GENUS FROM THE LOWER CARBONIFEROUS

CONTENTS

Occurrence of Paleozoic Ammonites.
Genus: *Prodromites* Smith and Weller, *gen. nov.*
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Conclusion.

Occurrence of Paleozoic Ammonites.—Until twenty-five years ago it was thought that the ammonites were confined entirely to the Mesozoic, and that the Paleozoic representatives of the Ammonitoid group were all goniatites. This was in keeping with the theory that ammonites all belonged to a single stock or phylum. But the discovery in the Salt Range Permian of several genera of different stocks that could not, by any stretching of the name, be called goniatites, upset this idea. For a long time after this the Permian ammonite fauna of India was looked upon as exceptional until the recognition of the Permian age of the ammonite fauna of the Artinsk beds of Russia. This was followed shortly by the discovery of similar forms in strata of the same age in Sicily and in Texas. It was then universally recognized that these forms were not exceptional, and might be looked for wherever the uppermost Paleozoic was found in its marine facies. But even as late as 1891 we find the Permian ammonite species of Texas described as Mesozoic types occurring in Paleozoic beds, and in all text-books even today the Permian epoch is given as the period of transition from goniatites into ammonites.

Steinmann and von Sutner[1] were the first to attempt to divide the ammonites into various phyla, derived from separate stocks of goniatites, and while their classification is not always in agreement with the most rational arrangement, it is very suggestive,

[1] STEINMANN: Elemente der Palaeontologie, 1890.

and has caused much fruitful discussion. The main points for which they contended have been accepted, and now it is generally admitted that ammonite genera may be much more closely related to goniatites than they are to contemporaneous or even antecedent ammonites. Karpinsky's[1] masterly researches in the phylogeny of the Prolecanitidæ contributed largely to this result, and prepared the way for Haug's[2] exhaustive study of the relations of the various phyla of goniatites.

When it is once admitted that there are several distinct stocks of different degrees of specialization and developing in different directions, there is no longer any sound reason for the commonly accepted opinion that they all made the transition at the same time; indeed, it is extremely illogical to expect that this would be the case. In spite of this, it will cause surprise, especially among those that cling to time-honored criteria, when it is announced that not only are characteristic ammonites found below the Permian, but even at the very base of the Carboniferous system, and in such an advanced stage of development that the transition from goniatite to ammonite must have taken place already in the Devonian. The occurrence of these forms is authentic, and not sporadic, for they were found in the same horizon, and in the same faunal association in three widely separated localities in America. It may be that they were prematurely specialized forms, like *Clymenia*, that developed suddenly from the main, unspecialized stock, and as suddenly became extinguished; but the existence of similar and evidently closely related forms in the Trias presupposes continuance of the stock. In reality, our knowledge of the various families of Paleozoic animals is as yet only fragmentary, and lack of record is no very strong argument against the occurrence of any group. We must remember that the greater part of the Paleozoic deposits are not now open to our inspection, and that whole faunal provinces and

[1] Die Ammoneen der Artinsk-Stufe. Mém. Acad. Impér. Sci. St. Petersburg, seventh series, Tome XXXVII, No. 2, 1889.

[2] Études sur les Goniatites. Mém Soc. Géol. France, Paléontol., Tome VII, No. 18, 1898.

regions are now obliterated, either washed away entirely, or covered by the sea, or concealed by later deposits. The first records in the rocks or in text-books do not, by any means, agree with the first appearance of any group in geologic history. This is clearly seen when one notes the constant pushing back of the records of the first appearance of types, that has taken place in the past ten years. Our ideas of the specialization of organic life in Cambrian and even pre-Cambrian time have had to undergo radical changes as the discoveries of new faunas have followed fast upon each other.

Genus, **Prodromites**, *gen. nov.*, Smith and Weller.

Type, *P.* (*Goniatites*) *gorbyi* Miller, 1891, Advance Sheets Seventeenth An. Rep. Geol. Survey of Indiana, p. 90, Plate XV, Fig. 1; and Seventeenth An. Rep. Geol. Survey of Indiana, 1892, p. 700, Plate XV, Fig. 1.

The type species was originally described as a goniatite, but a most liberal interpretation of that group could not include this form, which was assigned to that division simply because of its occurrence in Carboniferous rocks.

The genus *Prodromites*[1] is characterized by its laterally compressed, discordal, involute, deeply-embracing whorls, narrow umbilicus, high, hollow abdominal keel, and complex, ceratitic septa. Where the keel is broken off, as is usually the case, the abdomen is narrow, slightly flattened, and angular. The surface, so far as known, is smooth, and destitute of ribs, constrictions, or other ornamentation. The septation is the most distinctive feature of this genus, on account of the large number of serrated lobes, and an extensive auxiliary series of lobes and saddles. The ventral lobe is rather long and undivided, the saddles all rounded and entire, the first four or five lateral lobes are serrated, and in addition to these there is a series of several pointed and more or less irregular auxiliary lobes.

The only Paleozoic form to which *Prodromites* may be likened is *Beloceras*, which it resembles only in its compressed involute form and the multiplication of the elements of the septa. The resemblance is not great, but the agreement is fundamental, and these two genera may safely be placed in the same family or phylum. A much greater resemblance and probably kinship connects this form with *Hedenstroemia* Waagen, of the Lower Trias of the oriental region. The best known species of that genus is *H. mojsisovicsi* Diener, Pal. Indica, *Cephalopoda of the Lower Trias*, page 63, Plate XX,

[1] The etymology of the word is from the Greek of scout or forerunner.

Figs. 1 *a–c*. In *Hedenstroemia*, as defined by Waagen,[1] the ventral lobe is divided, the external saddle divided by adventitious lobes; the first four lateral lobes are serrated, and there is a series of about six pointed auxiliary lobes. The form is flattened, involute with narrow and angular abdomen. No keel is known, and the shell is smooth. In *Prodromites* the ventral lobe is undivided and the external saddle is entire and rounded; but in the serration of the first four or five lateral lobes and in the auxiliary series it is almost identical with *Hedenstroemia*, as also in the form, with the exception of the keel, which may not have been preserved on the few specimens known. There can be no doubt that these two genera belong to the same family, and even subfamily, in spite of the long time that intervened between the Kinderhook formation of the Lower Carboniferous and the Lower Trias. *Hedenstroemia*, according to Waagen,[1] belongs to the Pinacoceratidæ, subfamily Hedenstroeminæ, which also contains *Clypites* Waagen, and *Carnites* Mojsisovics, of the Lower Trias. The family Pinacoceratidæ in the broader sense, as defined by Waagen (*op cit.*, p. 139), contain all forms with compressed involute whorls, many lateral lobes and saddles, and an auxiliary series of lobes outside of the umbilicus. In this family belong the following subfamilies: (1) Medlicottinæ, (2) Beloceratinæ, (3) Beneckeinæ, (4) Hedenstroeminae; all of which have representatives in American Paleozoic or Triassic strata.

It is not likely that *Prodromites* is a descendant of *Beloceras*, since the septation is quite different in the two genera; and unless *Hedenstroemia* should be found to have a keel, it is not likely that it has descended from *Prodromites*. *Beloceras* is commonly placed under the Prolecanitidae, although it antedates any typical species of *Prolecanites*. On the other hand, *Medlicottia*, which is closely related to *Prodromites*, seems certainly to have been a descendant of the typical Prolecanitidæ. No solution of these questions is possible until the ontogeny of several of these genera is known, which is prevented at present by a scarcity of specimens. Until other evidence is forthcoming, *Prodromites* is placed in the family Pinacoceratidæ, subfamily Hedenstroeminæ.

This genus is not founded solely on Miller's figure, which is not accurate, nor even on his type specimen, but also on three other specimens of this species, and one of another species, bringing out certain characters that did not show on Miller's type.

The writers have had at their disposal for study four specimens of *Prodromites gorbyi* Miller, and one of *P. praematurus* S. and W., all of which, except one, belong to the paleontological collection of the Walker

[1] Pal. Indica. Salt Range Fossils. Fossils from the Ceratite Formation, p. 140.

[1] Pal. Indica. Salt Range Fossils, Vol. II. Fossils from the Ceratite Formation, p. 140.

Museum at the University of Chicago, to the authorities of which the writers' thanks are due for the use of the specimens. The first specimen,[1] No. 6208, is Miller's type of *Goniatites gorbyi*, and came from the Chouteau limestone at Pin Hook Bridge, Pettis county, Missouri. A second specimen, No. 6474, was secured from Professor G. C. Broadhead. It is better preserved than the type, but in the same sort of limestone, and while it is merely labeled "Chouteau limestone, Pettis county, Missouri," it probably came from the same locality as the type. A third specimen, No. 6222, is recorded merely from the Kinderhook beds of Burlington, Iowa. The material in which it is preserved is a buff or yellowish, rather finely crystalline limestone, the position of which in the Kinderhook section at Burlington is probably near the top, between the oolitic limestone and the buff magnesian bed, which lies immediately below the Burlington limestone of Osage age, or in the basal portion of the oolite bed. This horizon may then be correlated with the Chouteau limestone of central Missouri.

A fourth specimen of *P. gorbyi* was studied by the writers in the collection of Fred. Braun, of Brooklyn, N. Y. It came from the Kinderhook goniatite bed of Rockford, Indiana, associated with *Prolecanites lyoni* Meek and Worthen, *Aganides rotatorius* de Koninck, *Muensteroceras oweni* Hall, *M. parallelum* Hall, and thus is certainly in the zone of *Aganides rotatorius* of the Tournaisian horizon of the Lower Carboniferous.

A fifth specimen of the genus, No. 6223, belongs to a new species (*P. praematurus* Smith and Weller). It came from the Kinderhook goniatite beds of Rockford, Indiana.

Geologic horizon.—Since this genus occurs in the same horizon, in rocks of different lithologic character, and in three localities separated by hundreds of miles, it may be considered as characteristic of the Chouteau limestone horizon of the Lower Carboniferous, equivalent to the lower part of the Tournaisian horizon of the European Dinantian formation. At present *Prodromites* is unknown outside of America, and but two species are known, in the Mississippi valley region, from the three localities mentioned.

Prodromites gorbyi Miller. Plate VI, Figs. 1. Plate VII, Fig. 9. Plate VIII, Figs. 1, 2.

1891 *Goniatites gorbyi* Miller, Adv. Sheets, Seventeenth Rep. Geol. Survey of Indiana, p. 90. Plate XV, Fig. 1.

1892 *Goniatites gorbyi* Miller, Seventeenth Rep. Geol. Survey of Indiana, p. 700. Plate XV, Fig. 1.

Neither the description nor the figure given by Miller of this type is accurate, the drawings of the septa being entirely too generalized.

[1] The numbers refer to the Walker Museum collection.

The form is laterally compressed, involute, discoidal, with very narrow umbilicus. The abdomen is narrow, and surmounted by a high narrow hollow keel, which however is usually not preserved. Where the keel is broken away the abdomen is narrow, less than a millimeter wide, with angular edges.

The sides are smooth, devoid of constrictions, ribs, or other ornamentation, so far as could be determined from the casts.

The septa are complex, ceratitic, with many lobes and saddles. The ventral lobe is long and undivided. The external saddle is rounded and shorter than the laterals. The first lateral lobe is serrated, four-pointed; the second, four-pointed; the third, the three-pointed; the fourth, irregularly three-pointed; the fifth irregularly bifid. With the sixth lateral lobe begins the auxiliary series of goniatitic lobes, which are of irregular size, and eight in number, growing smaller towards the umbilicus. These characters could not be made out distinctly on Miller's type specimen No. 6208, but the details were clearly seen on specimen No. 6474, from the same locality. The differences between the two specimens, at a casual glance, might seem to be specific, but closer study shows them to be due to difference of preservation, and to different sizes at which the septa are seen. The type specimen shows the keel only at a few places on the periphery, and so indistinctly that Miller overlooked it, while No. 6474 shows the keel, 3½ millimeters high, entirely around the periphery. On both specimens the body chamber is incomplete and occupied a little over a quarter of the last revolution. It is not known what was the shape of the aperture, how long the body chamber was, when the keel began, nor what the internal lobes were like, since none of the specimens available sufficed to settle these questions.

A smaller specimen, No. 6222, from the Kinderhook beds of Burlington, Ia., showed much simpler septa, and the narrow angular abdomen with the keel broken off. It is undoubtedly in the beginning of the mature stage of growth, and was of value in showing the shape of the cross-section, since both sides were free from the matrix, while in all other specimens one side was fixed to the matrix.

At present there are known only four specimens of *Prodromites gorbyi*.

1. Miller's type, from the Chouteau limestone at Pin Hook Bridge, Pettis county, Missouri. No. 6208, Paleontological Collection, Walker Museum, University of Chicago. This is the type of the genus *Prodromites* Smith and Weller.

DIMENSIONS

Diameter	114mm
Height of last whorl	64
Height of last whorl from the preceding	35
Width of last whorl	..
Involution	29
Width of umbilicus	4

2. Specimen obtained from Professor G. C. Broadhead, Chouteau limestone, Pettis county, Missouri, probably from the same locality as the last. No. 6474, Paleontological Collection, Walker Museum, University of Chicago.

DIMENSIONS

Diameter	117[mm]
Height of last whorl	68
Height of last whorl from the preceding	38
Width of last whorl	..
Involution	30
Width of umbilicus	5?

3. Specimen from the Kinderhook limestone of Burlington, Ia., near the top of the Kinderhook Series as exposed at that locality. No. 6222, Paleontological Collection, Walker Museum, University of Chicago.

DIMENSIONS

Diameter	75[mm]
Height of last whorl	42
Height of last whorl from the preceding	25
Width of last whorl	10
Involution	17
Width of umbilicus about	4

4. Specimen from the Kinderhook goniatite limestone of Rockford, Ind.; in the paleontological collection of Fred. Braun, of Brooklyn, N. Y., where it was examined by the writers. Its dimensions are about the same as of the two specimens from Missouri.

Prodromites praematurus sp. nov., Smith and Weller. Plate VIII, Figs. 3, 4.

Type is specimen, No. 6223, Paleontological Collection, Walker Museum, University of Chicago. Form laterally compressed, discoidal, involute, deeply embracing, with narrow umbilicus, narrow slightly flattened abdomen surmounted by a hollow keel three millimeters high. Whorl indented by the preceding whorl to a little over one third of its height. Surface smooth, so far as known.

The septa are complex, ceratitic, with rounded entire saddles, serrated lateral lobes, and a series of auxiliaries above the umbilicus. The ventral lobe is narrow, and undivided; the first lateral is longer, and three pointed; the second lateral, four-pointed; the third lateral, bifid; the fourth lateral, bifid, but more deeply so than the third; then begins a series of auxiliary lobes, undivided and pointed, seven in number.

The only species with which *Prodromites praematurus* might be compared is *P. gorbyi*, from the same horizon; but in *P. praematurus* the abdomen is slightly broader, the shell rather thicker, the septa rather more complex, and the umbilicus slightly wider than on *P. gorbyi* at the same diameter. In the figures and the descriptions of the septa a difference between the two species may easily be seen.

DIMENSIONS

Diameter	62[m.m]
Height of last whorl	34
Height of last whorl from the preceding	21
Width of last whorl	9.5
Involution	13
Width of umbilicus	6.5

This specimen was septate throughout, so the length of the body chamber could not be ascertained.

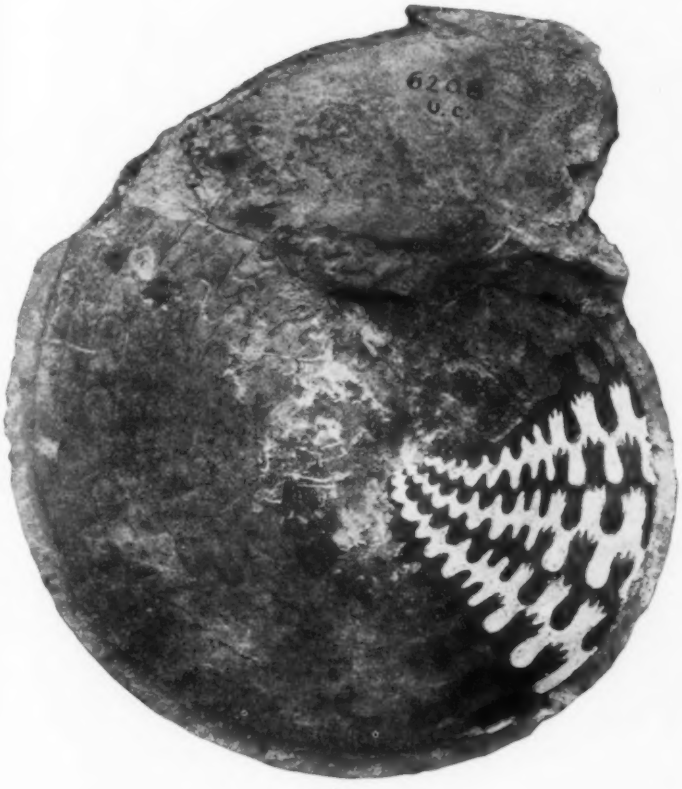
Only a single specimen is known, No. 6223, of the Paleontological Collection, University of Chicago, from the Kinderhook goniatite limestone of Rockford, Indiana.

CONCLUSION

In *Prodromites* we have the oldest known ammonite and the most complex ammonoid yet described from strata older than the Permian, occurring only a short distance above the base of the Lower Carboniferous. In all probability the ancestors of this genus had already become ammonites before the close of the Devonian, but we do not know where to look for them. The Kinderhook ammonoid fauna is exotic in America, and seems to be exotic wherever it is known. But in the faunal region from which this migration came we may expect to find a highly specialized fauna of which those forms that made their way into Europe and America in Tournaisian time are but a fragment. We have, as yet, no clue as to where this region was, but the vast unexplored Paleozoic stretches of Asia lead us to hope for much new information when that continent shall be thoroughly investigated.

The occurrence of such forms as *Prodromites*, without local ancestors serve only to emphasize our ignorance of the ancient zoology of regions outside our own, and should stimulate research in geographic distribution of fossil faunas.

JOUR. GEOL., Vol. IX, No. 3 Plate VI



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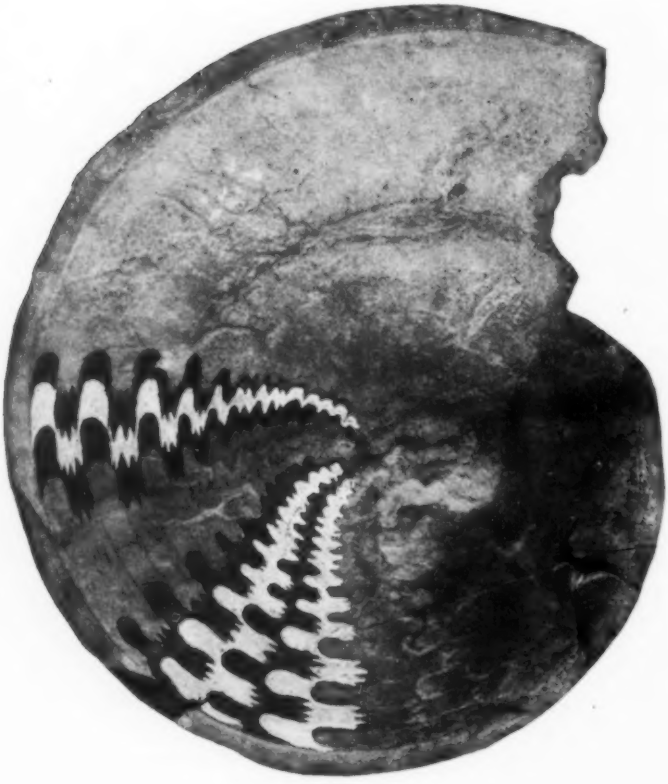
JOUR. GEOL., Vol. IX, No. 3 Plate VII



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JOUR. GEOL., Vol. IX, No. 3 Plate VIII

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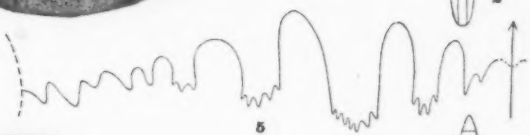

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EXPLANATION OF PLATES

(All figures are natural size)

PLATE VI

FIG. 1. *Prodromites gorbyi* (Miller). No. 6208 Pal. Coll. Walker Museum. Miller's type specimen from the Chouteau Limestone, Pin Hook Bridge, Pettis county, Missouri.

PLATE VII

FIG. 1. *Prodromites gorbyi* (Miller). No. 6474 Pal. Coll. Walker Museum. From the Chouteau Limestone, Pettis county, Missouri.

PLATE VIII

FIG. 1. *Prodromites gorbyi* (Miller). No. 6222 Pal. Coll. Walker Museum. From the Kinderhook beds, Burlington, Iowa.

FIG. 2. Front view of the same.

FIG. 3. *Prodromites praematurus* sp. nov. Smith and Weller. No. 6223 Pal. Coll. Walker Museum. From the Kinderhook Goniatite bed, Rockford, Indiana.

FIG. 4. Front view of the same.

FIG. 5. Septa of *Hedenstroemia mojsisovicsi* Diener. After C. Diener, Pal. Indica, series 25, Vol. II, Part II, Plate XX, Fig. 1*c*.

JAMES PERRIN SMITH,
STUART WELLER.

EDITORIAL

In the death of Dr. George M. Dawson, director of the geological survey of Canada, American geology has lost one of its ablest representatives. Not only as an individual worker, but as an administrator, he displayed unusual capacity and gave promise of still larger achievements in the future. That so promising a career should be cut short so suddenly at the climax of its productiveness is sad indeed, and the loss is keenly felt by the scientific world. When the vastness of the area whose investigation was being conducted under his direction, and its important relations to many of the great outstanding problems of geology, are recalled, the misfortune of the interruption of his successful administration and of his personal labors is most fully realized.

Dr. Dawson enjoyed unusual privileges of education and early association, which, combined with his native capacity for absorption and assimilation, gave him an unusual breadth of learning and catholicity of interest, and these qualities were called into active and manifold expression in the exposition of the broad and complex phenomena of the great Canadian field. He was gifted with notable literary abilities, and these, combined with a charming personality, gave grace and geniality to all his presentations. We hope to present a critical sketch of his work in a future number. T. C. C.

It is a hopeful sign for the future terminology of our science that manifestations of dissatisfaction with its current nomenclature are just now taking on active and declared forms. During the last few weeks conferences have been held in different quarters at which the improvement of existing usage has been the special subject of discussion. It is not proposed to dwell upon these here, though it is hoped that the Journal may have

something further to say upon the subject at an early date, but merely to say a word on the special issue raised by the articles of Messrs. Cumings and Siebenthal in this number, which appear together by mutual concurrence. These articles bring up the question how far the law of priority, rigorously interpreted, shall determine all subsequent usage, and how far other considerations may properly weigh against it. It appears that in this case the term "Bedford" was used by Owen as early as 1862 in describing the well-known Indiana formation; but that it was not then formally proposed as the scientific name of the formation. In 1870 Dr. Newberry proposed the name "Bedford shale" for an entirely different formation, found at Bedford, *Ohio*. Since then the term "Bedford stone" has become familiar throughout the country as the commercial designation of the rock so extensively shipped from the Indiana town, and this use will quite certainly continue in spite of any technical usage which geologists may propose. Two practical questions therefore arise:

1. Does the familiar use of a term in an official report as the designation of a given formation in any sense or to any degree preoccupy the term so that it may not be used advisedly as the formal name of any other formation, particularly a formation in the same geological province? Specifically, did the use of the term "Bedford rock" by Owen in any degree preoccupy the term "Bedford" so that it was improperly selected as the formal name of a formation in Ohio?

2. Does the growth of such a name into very common usage, together with the certainty that this common usage must prevail in spite of any technical practice that may be adopted by geologists, constitute a sufficient reason for not applying the term technically to any other formation in the same province?

There is also the more general question, whether our science should be burdened for all time to come by infelicities in the choice of a name made by a busy worker who may have been able to give but a passing thought to the selection of a name, and who may have been unaware at the time of the infelicities likely to arise out of it. In short, shall the rule of priority, rigidly

and technically interpreted, be observed for all time, however infelicitous it may prove to be?

These are questions upon which at present there are differences of opinion. It seems altogether wise to keep them in a state of agitation until geological opinion shall formulate itself on mature and permanent grounds. We are passing from the initial stages of our science, in which the discovery of formations, like the discovery of animal and plant species, has predominated, into a more mature stage, in which these elements will lose their importance through the recognition of gradations, of evolutions, and of those broader and profounder relationships which will constitute the really important phases of the subject to future students. It is fitting, therefore, that we should consider whether the verbal lumber that may have had importance in the initial stages shall be transmitted, without modification or adaptive evolution, to the whole future of the science. To the writer it seems important to the future of the science that its language should be developed along the lines of greatest serviceability and esthetic merit. It seems, furthermore, quite possible to give all due honor to the initial discoverer without injury to the language of the science; indeed, it would seem in some instances that the initial discoverer would be honored by the rejection or the modification of his unfortunate nomenclature. Is it not within the limits of permissible practice to set aside an unfortunate name and to substitute a new one, and at the same time leave the credit of primal identification to the original author? It does not seem that priority of discovery and of description is inseparably connected with priority of nomenclature.

It is not the purpose of this note, nor the policy of the JOURNAL, to urge at once a decision in this special case or in similar cases, but rather to urge that the question of nomenclature be kept open and be the subject of thoughtful study until all of the considerations that should enter into the formation of the language of the science have been brought forth into distinct recognition and have been duly pondered. After

sufficient time has been allowed for a deliberate consideration on these broader lines, and a consensus of opinion has been matured as a result, general rules may perhaps be reached. Meantime a measure of freedom may be allowed to individual judgment. T. C. C.

THE writer has read the proof of the article "On the use of the term Bedford limestone," by Mr. C. E. Siebenthal, which appears in this number of the *Journal of Geology*. Mr. Siebenthal's argument in reference to "the prior claims of Indiana to Bedford as a formation name" rests entirely upon the occurrence of the term "Bedford rock" in Owen's report on Lawrence county, published in 1862, which we have shown was *not* used in the sense of a formation name and was not described. The sentence in which "Bedford rock" occurs is as follows: "The Bedford rock has long been celebrated for its excellent qualities as a building stone, and is extensively shipped; additional localities are being opened, and only require the liberality of railroad directors to furnish switches and other facilities for still more extended sales."[1] The name was used in the same sense as the names of hundreds of other towns have been applied to the rock quarried in their vicinity but without any intention to have them serve as the names of geologic units. If they were recognized as formation names the number of synonyms for the consideration of the stratigraphical geologist would be enormously increased.

Bedford shale was published as the name of a geological division by Dr. Newberry in 1870[2] and fully described by him in 1873.[3] Following the single occurrence of "Bedford rock" in Owen's report the next citation of "Bedford stone" by Mr. Siebenthal is from the Indiana report for 1873, published in 1874,[4] in which Professor John Collett described the "Geology

[1] Rept. Geol. Reconnoissance Indiana, 1862, p. 137.

[2] Rept. Geol. Surv. Ohio, Pt. I, Rept. Progress in, 1869, p. 21.

[3] Rept. Geol. Surv. Ohio, Vol. I, Pt. I, pp. 188, 189.

[4] Fifth Ann. Rept. Geol. Surv. Indiana made during the year 1873–4, p. 276.

of Lawrence county" and under the geological division of the St. Louis limestone, which was composed of beds No. 24–17 inclusive, he stated that "bed No. 22, is the quarry bed which furnishes in unlimited supply the famous 'Bedford stone' so favorably known. . . . . This stone is composed almost wholly of minute fossils cemented with shell and coal dust. It varies in color from gray to a creamy white, and may be quarried in blocks or columns the entire thickness (12 feet) of the stratum."[1] Under the geological section of the county bed No. 22 is described as "White quarry limestone" from 4 to 12 feet in thickness.[2] It is evident on reading the report that Professor Collett did not use the term "Bedford stone" as the name of a geologic unit. Furthermore, this report and the following citations by Mr. Siebenthal have no bearing upon the question of the priority of Bedford as a formation name because they are all antedated by Dr. Newberry's precise delimination and description of the Bedford Shales of northern Ohio.

Mr. Siebenthal's second point that "to the trade, *Bedford stone* it will be to the end of the chapter" does not appear to the writer to have any particular bearing upon the question. He does not believe when a scientific classification and one used in trade fail to agree that it is necessary for the former to withdraw in favor of the commercial one. A still more striking example of the difference between the trade and geological name is that of the "North or Hudson River bluestone," the trade name used for the sandstone so largely employed for flagging and house trimmings in New York and other eastern cities. The trade name was in use before the rocks of eastern New York were classified; but the geologists did not use it for the name of a geological division, although the name Hudson River group was used for an older formation than the one in which the quarries were located. The belt of country containing this "bluestone" extends for nearly one hundred miles north and south on the western side of the Hudson River and the early quarries were in

[1] Fifth Ann. Rept. Geol. Surv. Indiana made during the year 1873–4, p. 276.

[2] Loc. cit., p. 265.

rocks of the Hamilton formation. As these were partially exhausted new quarries were opened to the westward in rocks of the Sherburne formation, and later farther west in the Catskill Mountain region in rocks of the Catskill formation. At the present time the greater part of the "bluestone" is obtained from the Sherburne and Catskill formations; but to the trade it is all generally known and sold as the "Hudson River bluestone."

The name Bedford shale was given by Dr. Newberry to the geologic unit which is well exposed at Bedford village, southeast of Cleveland. The formation varies in thickness from fifty to one hundred feet; is sharply defined lithologically with its base resting on top of the black Ohio shale while its top is marked by the base of the Berea grit. In distribution it extends from eastern Ohio across the northern part of the state to Huron county, and thence south across the state to the Ohio River and into Kentucky. At a few localities in northern Ohio, especially near Cleveland, the shale includes from fifteen to twenty feet of valuable sandstone which is used considerably in that city for flagging and building stone. The Bedford shale of Ohio is as thick a formation as the Bedford limestone of Indiana; lithologically it is more sharply limited; it has, apparently, as great areal distribution; as the name of a definite geologic division it has appeared in geological literature for a longer time and to a much greater extent; but it does not contain as valuable economic deposits of building stone.

CHARLES S. PROSSER.

May 2, 1901.

Reviews.

The Norwegian North Polar Expedition, 1893–1896. Scientific Results. Vol. II. Edited by Fridtjof Nansen. Longmans, Green & Co., London, New York, 1901. VI. H. Geelmuyden, *Astronomical Observations*, pp. 1–136, with two charts. VII. Aksel S. Steen, *Terrestrial Magnetism*, pp. 1–196, with 17 plates. VIII. O. E. Schiøtz, *Results of the Pendulum Observations and some Remarks on the Constitution of the Earth's Crust*, pp. 1–90.

The astronomical observations have their chief geological value in the accurate determination of localities. While they are thus fundamental and indispensable, they afford in themselves little matter of note for the reviewer. The observations were chiefly made by Captain Sigurd Scott-Hansen. They are abundant and bear evidence of having been taken with accuracy, and they thus contribute a valuable precision to all other observations dependent upon locality.

The second part of the volume is devoted to the discussion of the magnetic observations of the expedition, which were also made by Scott-Hansen. Concerning the value of these observations, Mr. Steen remarks: "It is of especial importance to obtain determinations of the magnetic elements from the polar regions, because the observations have naturally hitherto been rather scarce from these deserted wastes, containing large tracts where the foot of man has never yet trod, and whose physical conditions place all kinds of difficulties in the way of delicate scientific investigations. They are also important because the action of the earth's magnetic forces in these very regions, judging from the observations that have been obtained, presents peculiarities to which there is no parallel in the temperate and torrid zones." The general results are summarized in tables giving the declination, horizontal intensity, and inclination at the numerous localities of observation.

The third part, which relates to pendulum observations, has, without doubt, the greatest interest for geologists. These pendulum

observations are the first systematic determinations of the force of gravity over the great ocean depths. "The observations show that the gravity may be regarded as normal over the polar basin; and as it is not probable that this is a peculiarity of the Polar Sea, we are led to the assumption that the force of gravity is normal all over the great oceans. The increased attraction observed on oceanic islands must therefore only be due to the local attraction of the heaped-up masses at the bottom of the ocean that form the islands" (p. 63). This determination of the normal character of the force of gravity over the ocean depths, if its theoretical extension to all the ocean basins be justified, must be regarded as a contribution of the first order. The determination in the polar basin was made possible by the relative fixity of the vessel in the ice. The tremors which more or less constantly affect the polar ice sheets may perhaps have slightly influenced the results but probably in no serious way. Regarding the theoretical extension, it is however to be noted that these polar observations were nowhere made at a great distance from the edge of the continental plateau, and that the extent of the depression is undetermined, and that, furthermore, the depth of the sea is somewhat less than the average depth of the ocean. The polar basin is probably not, at most, much greater in extent than the Mediterranean basin, and may be much less. It would seem, therefore, that some reserve may be prudently exercised in accepting the assumption that the observations in the Polar Sea determine the force of gravity over the great ocean depths in general. In view of the importance of determining this beyond question, it may be suggested that attempts be made to make pendulum observations in the calm belts of the tropics. This suggestion is made on the assumption that the sea might there be found sufficiently calm to permit observations of approximate accuracy.

The discussion of the crust of the earth, which follows that of the pendulum observations, is less satisfactory than it might have been, owing to the limitation of the theoretical assumptions to a single line of hypothesis. Apparently the results might be appreciably different, if different hypotheses of the internal constitution of the earth had been assumed. The discussion proceeds upon the conception that all the differences in the density of the solid portion of the earth are confined to its superficial portion. This is doubtless in accord with present majority views based on deductions derived from prevalent theories as to the origin and early state of the earth, but it is none the

less unsatisfactory, because it involves some assumptions which are apparently incompatible with the necessary deductions of physics, and which must probably be abandoned, whatever may happen to speculative views of the earth's genesis. For example, it is assumed that there is now an inner nucleus of uniform density forming a perfect spheroid, and that the outer surface that is now the ocean bottom was originally nearly or quite on a level with that on the continents, and that the present oceanic depressions are the result of progressive sinking due to cooling. Lord Kelvin, however, is authority for the statement that "there seems to be no possibility that our present day continents could have risen to their present heights, or that the surface of the solid in its other parts could have sunk down to their present ocean depths, during the twenty or twenty-five million years which may have passed since the *consistentior status* began or during any time however long." (On the Age of the Earth as an Abode Fitted for Life, p. 706.) And this conclusion is supported by independent considerations. The thickness of the earth's crust is taken by Professor Schiötz to be 0.02 of the earth's radius, or about eighty miles. If as supposed it rests upon a spheroidal nucleus of uniform density and perfect form, the difference in thickness in different parts amounts to fully 10 per cent. of its own thickness when reckoned only between plateaus and antiplateaus, neglecting mountain heights. A *difference* of contraction to the amount of 10 per cent. is quite incredible, as is also any remote approach to this amount. The *average* difference between the thickness of the crust beneath the continental plateaus and that beneath the ocean bottoms is, under the assumption made by the author, more than 3 per cent. of the whole crustal thickness, and this is more than can reasonably be attributed to any *difference* in contraction due to cooling. In view of these and other considerations, it would have been more satisfactory if the discussion had been extended to the postulates of other hypotheses of the inner constitution of the earth: among them, the assumption that an uneven distribution of density reaches to profound depths.

Nevertheless, it is a great gain to the study of the earth's dynamics that a treatment of the problem from the point of view of pendulum data extended to the ocean surface has been ventured, even though it be confined to a single line of hypothetical postulates.

T. C. C.

Meteorological Observations of the Second Wellman Expedition. By EVELYN B. BALDWIN, Observer, Weather Bureau. Report of the Chief of the Weather Bureau, United States Department of Agriculture, 1899–1900. Part VII. Washington, 1901.

This report embraces in full detail the meteorological observations made by Mr. Baldwin in connection with the second Wellman expedition. The observations relate especially to the meteorological conditions at and in the vicinity of Franz Josef Land, from June 1898, to August 1899, embracing observations made on shipboard between Tromso, Norway, and Franz Josef Land, those made at Harmsworth House and at Fort McKinley, on Franz Josef Land, and those made in the field, partly on Franz Josef Land and partly on the ocean north of there. To atmospheric geologists, the summations relative to the prevalent direction of the wind and cloud movements will perhaps possess the greatest interest. These show that the prevalent atmospheric movement was emphatically from the northward. The observations upon the upper clouds, which perhaps best express the general movement, may be grouped as follows:

N. W.	19 per cent.	
N.	20 per cent.	
N. E.	19 per cent.	
E.	10 per cent.	
		68 per cent.
S. E.	4 per cent.	
S.	2 per cent.	
S. W.	2 per cent.	
W.	6 per cent.	
		14 per cent.
Calms		18 per cent.

Fifty-eight per cent. are from N. W., N., and N. E., while only 24 per cent. are from the remaining five points.

Separating these into those that have an easterly and westerly component, the observations take this form:

North		20 per cent.
With easterly component:		
N. E.	19 per cent.	
E.	10 per cent.	
S. E.	4 per cent.	
		33 per cent.

With westerly component:

N. W.	19 per cent.	
W.	6 per cent.	
S. W.	2 per cent.	
		27 per cent.
South		2 per cent.
Calm		18 per cent.

From these data it will be seen that there is but very slight preponderance of the easterly component over the westerly, and that the aggregate direction is almost due north.

Analyzing in a similar way the observations on the lower clouds, we have:

N. W.	13 per cent.	
N.	20 per cent.	
N. E.	25 per cent.	
E.	5 per cent.	
		63 per cent.
S. E.	7 per cent.	
S.	6 per cent.	
S. W.	15 per cent.	
W.	6 per cent.	
		34 per cent.
Calm		4 per cent.

Summing up with reference to eastward and westward components, we have the following:

North		20 per cent.
With easterly component:		
N. E.	25 per cent.	
E.	5 per cent.	
S. E.	7 per cent.	
		37 per cent.
With westerly component:		
N. W.	13 per cent.	
W.	6 per cent.	
S. W.	15 per cent.	
		34 per cent.
South		6 per cent.
Calm		4 per cent.

The result is practically the same as before.

The emphatic preponderance of northerly winds, and the slightness of the average deviation to the east over that to the west, are

points of interest and should receive the consideration of the advocates of a "circumpolar whirl." Of course, conclusions are not to be drawn from these limited data (and data taken in an expedition of this kind are necessarily limited), but they are in consonance with many other data that invite a reconsideration of prevalent theories of atmospheric circulation.

When the conditions under which these observations were made are considered, their number and their nature must be regarded as a high tribute to the scientific devotion of the observer.

T. C. C.

The Oriskany Fauna of Becraft Mountain, Columbia County, N. Y. By J. M. CLARK, Ph.D., Mem. N. Y. St. Mus., No. 3, Vol. III.

Becraft Mountain is an outlier composed chiefly of strata of early Devonian age, resting conformably upon the upturned slates of the Hudson River formation. A preliminary paper on the fauna of the Oriskany formation at this locality was published in 1899 by Professor C. E. Beecher, being accompanied by a list of the species present identified by the author of the present report. It was shown at that time that the fauna was a peculiar one, consisting of an intermingling of Helderbergian and Oriskany forms. The present report is a detailed description of the fauna accompanied by good illustrations of all the species.

This discussion of the Becraft Mountain Oriskany fauna by Dr. Clark, brings clearly into view a very different conception of the faunas of Oriskany age in eastern North America from that which has become known through Volume III of the New York Paleontology. At Becraft's Mountain, and in strata extending southward through New York and into New Jersey, a calcarious facies of Oriskany sedimentation occurs, which contains a very different assembly of organisms from that of the original Oriskany sandstone, and which is considered by Dr. Clark as being the normal fauna of the period. In this connection Dr. Clark writes: "In the earlier presentation of this fauna it was regarded as of Lower Oriskany horizon, on account of the presence of many Helderbergian species, but we believe it will be more correctly construed as the representation of the proper and normal Oriskany fauna, the true fauna of this time unit inclosed in the sediments of its proper habitat."

The character of the Oriskany sandstone deposits in New York

from Schoharie county westward are shown to be "a series of arenaceous lenses connected by thin sheets of quartzitic sandstone." In regard to the fauna of these lenses, it is said: "The great brachiopods, *Spirifer arenosus*, *Rensselaeria ovoides*, *Hipparionyx proximus*, and *Meristella lata*, with *Tentaculites elongatus*, which are the species generally present in these lenses, could not have had their habitat on such a deposit and in a sea whose depth favored such deposition. We shall not be wrong in regarding these accumulations of remains in the true Oriskany sandstone as agglomerations, swept out of their facies and away from the more calcareous, deeper water deposits of the time. To regard them as species of the sandy facies of Oriskany time would, I believe, be altogether erroneous. They appertain truly to the calcarious facies and the normal fauna of the Oriskany time."

In the summation of the fauna, ninety-four clearly defined species are recognized, of which "thirty-eight represent expressions of species which began their existence in Helderbergian time; on the other hand but eighteen species of the fauna continue their existence or appear to be represented by closely allied forms beyond the close of the Oriskany sedimentation." Twenty-nine species of the fauna are recognized in the arenaceous Oriskany beds.

The evidence afforded by this fauna as the true Siluro-Devonian boundary line is of much importance. No one disputes the Devonian age of the Oriskany formation, and this fauna demonstrates that there is no natural faunal break in passing from the Helderbergian to the Oriskany, as there should be if the Helderbergian was excluded from the Devonian.

The closing pages of the report are devoted to somewhat minute discussion of the Silurian and Devonian characteristics of the Helderbergian fauna, both the positive and the negative elements being considered, and to a discussion of the stratigraphic argument based upon the relationships of the Maulius limestone.

S. W.

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